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Joint command, control and communications: an army perspective

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JOINT COMMAND, CONTROL AND COMMUNICATIONS: AN ARMY PERSPECTIVE

by

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June, 1994

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After establishing a baseline of Army structure and communications, a discussion of the Unified Command command and control architecture ensues. The Joint Task Force and separate Service communications responsibilities are then delineated. Discussions on joint communications interoperability and existing trends are included. Trends of note are the increase in reliance on satellite communications and bandwidth requirements in support of bulk data transmission.

The running themes throughout this thesis are doctrine and technology. These are two of the primary drivers for future communications architectures. Thus there is a focus on the current status of joint doctrine and existing communications equipment in the Army inventory. To highlight future Army systems requirements, a scenario is described.

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Joint Command, Control and Communications: An Army Perspective

by

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This thesis discusses the Army's structure, communications architecture, communications system and equipment, and communications-electronics role in the Joint Task Force. It provides readers an understanding of current Army systems and frames requirements for their evolution. The intended audience is other than Army. Accordingly Army structural and communications parochialisms are described.

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I. INTRODUCTION

A. GENERAL

The United States is in the midst of historic changes. The fall of the Soviet Union has driven a re-evaluation of our National Military Strategy. A strategic shift from global and theater warfare to crisis operations is underway. Underlying this is the ongoing reduction in Service force levels. Austere forces, capable of responding to a wide spectrum of contingency operations, must inherently be rapidly deployable and lethal. Wars of attrition are no longer feasible. Rapidly deployable forces capable of a variety of operations equate to joint force composition. The need for effective joint operations has led to a renewed emphasis on the Joint Task Force (JTF).

Joint Operations have been ongoing since the Revolutionary War.[1] Inter-service communications interoperability and coordination in support of Joint Operations have been, and are currently, effected with a "band-aid and bailing wire" approach.[2] This haphazard technique is derived from intra-service communications interoperability concerns, inter-

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[1] For a discussion on the evolution of joint mechanisms for force projection see Cushman, June 1991, pp. 27-48.

[2] Work-a-rounds are discussed in Cushman, June 1991, p.3, p.4 and JCS Manual 525-10, 1988, pp. 1-3, 1-7.

service communication equipment incompatibilities and a lack of succinct Joint Doctrine. In the past these issues were overcome with liaison teams. Reducing force levels and budgets will not support the manpower and assets required for a liaison team intensive structure. (Information Mission Area White Paper, 15 October 1993, p. 1)

Service specific command, control and communications (C3) systems are designed to support command and control (C2) architectures that have developed under the auspices of the Cold War threat. Each Service was focused on their roles in an anticipated global war. Intra-service communications developed accordingly. This has led to a divergence in inter-service communications systems.

Technological advances and the fall of the Soviet Union have antiquated many Service C3 concepts. The challenge to the services is to develop C3 systems and C2 architectures that effectively exploit technological advances and are interoperable. The JTF's Joint Communications Network (JCN) must be capable of providing a timely, seamless and synergistic view of the battlefield.

In support of the JTF JCN the Services must implement strategies to bring about a convergence of communications equipment interoperability. Effective C2 architectures and C3 systems are a relatively untapped force multiplier that must be exploited.

B. PURPOSE

To be an efficient manager and user of a system one must know its capabilities and limitations. In support of this endeavor the Joint Command, Control, Communications, Computers and Intelligence (JC4I) Systems curriculum provides students a Joint view of C4I. The purpose of this thesis is to provide an in-depth examination of the Army's structure, C2 architecture, communications equipment and communications responsibilities in the JTF. Additionally this thesis provides insights into the future Army C2 architecture, C3 systems and its role in joint operations.

C. ORGANIZATION

This document is organized into five chapters. The first chapter provides the general framework and purpose of the thesis. A scenario is also included. The intent of the scenario is to provide a focal point for examining a possible future C3 system. The second chapter provides the reader a baseline understanding of the Army's tactical C3 system and C2 architecture. The architectural information is taken directly from Army Field Manuals. The discussion in this chapter includes a perspective on the ongoing evolution of the Army's C2 architecture. The third chapter is a description of the Army's tactical communications system (i.e., Mobile Subscriber Equipment (MSE)). This chapter provides an understanding of

MSE employment and an in-depth description c communication assemblage capabilities. Equipment descriptions were extracted from contractor provided materials. Chapter IV provides the template for Unified Command and JTF C2 architecture under which the Army must operate. Included in the chapter is an itemization of Service communications responsibilities and communications interoperability performance. The bulk of information from this chapter was derived from Desert Shield/Desert Storm lessons learned and Joint Publications. Chapter V provides a recapitulation of Army communications interoperability and illuminates requirements of the future C3 system. This chapter presents the conclusion of the scenario presented in the first chapter.

D. SCENARIO

The following is a scenario to illustrate future C3 requirements and a possible solution thereto. It is focused on the initial operations conducted by the Commander of Land Forces (in this case, Army).

Downsized forces and a shrinking defense budget has resulted in an increased reliance on technology to provide the force multiplier.[3] Increased world tensions have driven the National Military Strategy to shift focus from a global and

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[3] Paraphrased from a quote by General Colin L. Powell found in the *Information Mission Area White Paper*, 15 October 1993, p. 1).

theater war scenario to a multi-crisis scenario in various theaters. In support of the changing world scenario the Army has reorganized from divisions into Strike Teams (ST). The Strike Teams are division-sized and designed to exploit technical assets over widely dispersed areas. The intent is to provide maximum kill power from weapons platforms available. To reduce force exposure, over-the-horizon target identification, tracking, acquisition and engagement has become the combat engagement norm. The Strike Teams rely heavily on intelligence of enemy location and composition for the targeting of advanced and limited munitions. Accordingly, look-shoot-look is enforced.

1. The Warning Order

a. *Situation*

Southeast Asia. Western Calmorn has claimed historical sovereignty over Eastern Calmorn. An invasion of Eastern Calmorn is eminent (within 72 hours). Eastern Calmorn is of strategic importance to the U.S. for its production of Situponide, a critical element in the production of composite materials.

Enemy. Western Calmorn's Army consists of three modern equipped divisions (two armored (AR) and one Infantry (IN)). One AR division is currently massed on the border with Eastern Calmorn. The other AR division is maintaining garrison positions along its supplemental landlocked borders. The

Infantry Division is garrisoned within the Western Calmorn capital to insure civilian acquiescence.

Friendly. The 12th Strike Team (ST), currently located at Fort Shafter, Hawaii, is to deploy its three brigades (aviation, armor, infantry) to Eastern Calmorn. Air Force and Naval assets are available for support. Eastern Calmorn's forces are limited to lightly armed border forces and antiquated reconnaissance aircraft. Equipment for the AR Brigade is prepositioned in the Southwest Pacific. Transit time to Eastern Calmorn by Roll-on-Roll-off (RORO) seaborne vessels is 24 hours.

b. Mission

The 12th ST is to prepare to conduct offensive operations to repulse and destroy all military elements of Western Calmorn which penetrate the border of Eastern Calmorn. Sovereignty of Eastern Calmorn must be maintained. Specific tasks include restoration of border, security of the Situponide mines and security of air and sea ports as required.

c. Execution

Eastern Calmorn's forces will provide initial screening and border penetration alert. U.S. AWACS, JSTARS and National Technical Means will be active and available for support in the region prior to Army Strike Team arrival. Speed is of the essence. Preparatory fires (at border penetration)

will be conducted by Naval Gun Fire. Combat Air Support is available from the Task Force Navy, Marine, and Air Force components. The 12th ST Aviation brigade is to engage and destroy the enemy far forward. Security can be provided for 12 hours (nominal) to allow linkup with RORO transported equipment. The 12th ST AR brigade must be prepared to continue the attack, conduct mop-up, and re-establish the border. The 12th IN brigade will conduct airborne operations to secure Pokimp International and Gutae Air Ports, and the Situponide mines.

d. Service Support (Not Applicable)

e. Command and Signal

Signal. All call signs and frequencies are in effect per Joint Standard Operating Procedures (JSOP). Call signs and frequencies are available on the Revised Battlefield Electronic Communications-Electronics Operation Instructions (CEOI) System (RBECS) (an automated CEOI).

Command. JSOP's are in effect.

2. Commander's Thoughts

The Strike Force commander has been identified as the Commander Land Forces (COMLANFOR). Because speed is of the essence the commander feels an immediate surgical strike from his aviation brigade will effectively halt the enemy advance. The key to his plan is knowing the enemy's exact composition and location. The commander envisions his phased employment as

1) air insertion of the infantry brigade to secure airports to support Army aviation operations, 2) the aviation brigade will fly to secured airports (air refueling en route), 3) the armor brigade will fly in to East Calmorn and effect link up with RORO transported equipment. Foremost in the commander's mind is acquisition of the enemy's forces. Time may not permit employment of the armored brigade. He must minimize exposure of his engaged forces and inflict maximum damage to the enemy. This inherently dictates over-the-horizon engagements or, at a minimum, engagement at the outer envelope of the enemy's fan of fire. Target identification and selection will have to be done "on the fly." The mission weighs heavy on his mind as he boards his newly fielded Army Tactical Command and Control Airborne Platform (ATC2AP).

II. AN ARMY OVERVIEW

A. U.S. ARMY TACTICAL STRUCTURE

The fundamental objective of our National Military Strategy is to deter aggression. U.S. forces must be able to respond rapidly to deter and, if necessary, to fight and win. Forces that the Army can deploy rapidly in support of National Military Strategy are corps size and below. (National Military Strategy of the United States, 1992, pp. 6-7)

Tactics is defined as "the science and art of maneuvering forces in combat" and strategy as "the science and art of military command employed with the objective of meeting the enemy under conditions advantageous to one's own force."[4] A corps is the largest entity which can be maneuvered in combat. Ergo Corps sized units and below are considered the tactical level of the Army. Although a Corps can be employed in a stratagem, strategic deployment is most often conducted at the Army level. The remainder of this section will focus accordingly.

1. Branches of the Army

There are 20 branches in the Army. The branches are classified in one of three categories. The categories are Combat (C), Combat Support (CS), and Combat Service Support

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[4] Merriam-Webster, July 1978, p. 695, p.676.

(CSS). Branches that maneuver against the enemy are in the combat category. Units in direct support of combat units are combat support. Combat service support is composed of logistic and general support branches. Branch by category is indicated in Table I.

Table I. BRANCH BY CATEGORY

Combat	Combat Support	Combat Service Support
Air Defense Artillery	Chemical	Adjutant General
Armor	Engineer	Civil Affairs[5]
Aviation	Military Intelligence	Chaplin
Infantry	Military Police	Finance
Field Artillery	Signal	Judge Advocate General
Special Forces		Medical
		Ordnance
		Quartermaster
		Transportation

2. Echelon Description

A quick rule of thumb in remembering the basic structure of the Army is "three and one." At each level there are three maneuver or "line" units and one support unit.

[5] Reserve component only.

Example: a battalion has three line companies and one headquarters (HQ) company. This rule of thumb is not a panacea for understanding the in-depth composition of all echelons. But it is a bench mark for the major subordinate units within a command. Although there are variations between unit types the fundamental concept remains sound. In descending order the echelons of the U.S. Army structure are army, corps, division/group,[6] brigade/regiment,[7] battalion/squadron,[8] company/troop/battery,[9] platoon, squad, and section. The following is a brief description of the levels from corps through company.

a. Corps

The major maneuver units within a corps are divisions. Corps may be assigned divisions of any type (see Subsection b. below) as required by the theater and the mission. A corps normally has two to five divisions of any type and combination. Historically, during peacetime, corps have had three divisions. (FM 100-15, 1989, p. 2-3)

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[6] Both are equivalent in size. Group is normally associated with a support organization.

[7] A regiment is equivalent to a separate brigade. Regiment is associated with the cavalry.

[8] Both are equivalent in size. Aviation and cavalry battalions are called squadrons.

[9] All are equivalent. Troop is used by the cavalry. Battery is used by FA and ADA.

A corps possesses support commands and are assigned combat and combat support organizations based on their needs for a specific operation. Armored Cavalry Regiments (ACR), field artillery brigades, engineer brigades, air defense brigades, and aviation brigades are the non-divisional units commonly available to the corps. Separate infantry or armored brigades may also be assigned to corps. Combat support organizations present in the corps are signal brigades, military intelligence brigades, military police brigades, civil affairs brigades, chemical brigades, and psychological operations battalions. Other Special Operations Forces (SOF) may support corps combat operations as required, particularly when the corps is conducting an independent operation. The combat service support organizations of the corps are the personnel group, the finance group, and the Corps Support Command (COSCOM). Figure 1 depicts a typical corps organization.[10] (FM 100-15, 1989, p.1-0)

[10] See Appendix B for symbology. (FM 101-5-1, October 1985)

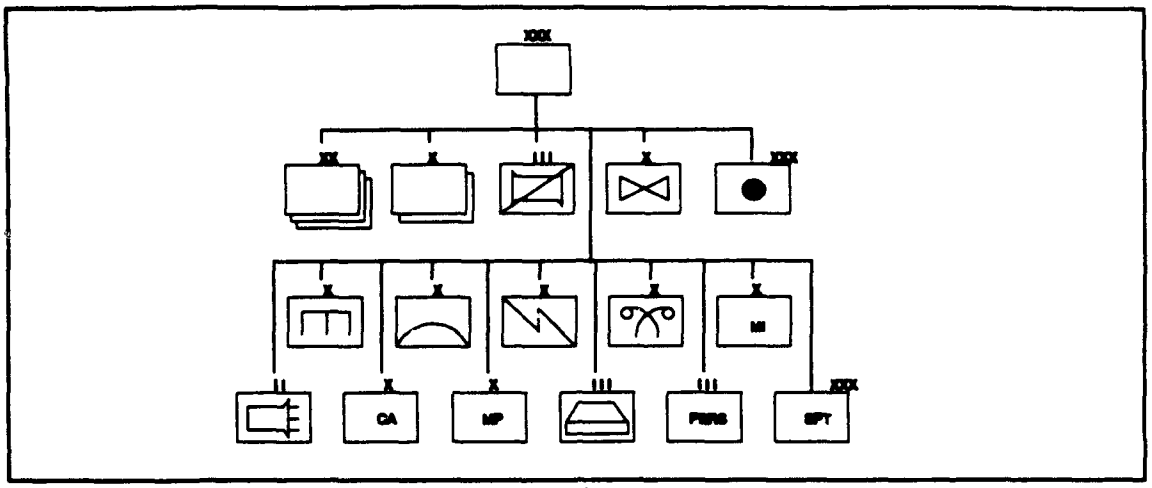

Figure 1. Typical Corps Organization

b. Division

The major maneuver units of a division are brigades. Normally a division has three ground maneuver brigades and one aviation (rotor) brigade.

Divisions are fixed combined arms organizations capable of performing any tactical mission and are largely self-sustaining. They are the basic units of maneuver at the tactical level and perform major tactical operations for the corps. (FM 100-15, 1989, p.2-3)

Additional combat units of a division are ADA battalion, engineer battalion, and FA brigade[11]. Signal battalion, MI battalion, MP battalion, and a Chemical Company are the usual combat support organizations present in a division. The major combat service support organizations are

[11] Called Division Artillery (DIVARTY), has three subordinate FA battalions.

a personnel services element and the Division Support Command (DISCOM)[12].

Division types presently in the U.S. force structure are infantry, light infantry, armored, mechanized infantry, airborne and air assault. Following is a summary of division type capabilities. (FM 100-15, 1989, p.2-3)

(1) Infantry Division. The infantry division is predominately a dismounted force, capable of operations across the entire spectrum of conflict. The division possesses organic light (non-armored, i.e., High Mobility Multi-Wheeled Vehicles (HMMWV), two and a half ton trucks, five ton trucks, etc.) transportation assets. It is best suited for terrain and environmental conditions that limit the operations of a heavy force. Urban and jungle areas are examples of terrain appropriate for dismounted "straight-leg" infantry. (FM 100-15, 1989, p. 2-3)

(2) Light Infantry Division. The light infantry division is designed for rapid deployment to enable them to arrive in a crisis area before a conflict begins. They are capable of operating for 48 hours without resupply. These are offensive oriented units well adept at operating in low intensity scenarios. (FM 100-15, 1989, pp. 2-3,2-4)

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[12] There are three subordinate battalions to DISCOM. These are called Forward Support Battalions (FSB's).

(3) Armored and Mechanized Infantry Divisions. The armored and mechanized divisions are mobile, ground gaining forces with significant armor protected firepower (tanks, Bradley Fighting Vehicles (BFV's), Armored Personnel Carriers (APC's), etc.). They are referred to as heavy divisions and are what the layman would consider a typical Army division. These divisions operate most effectively in terrain where they can move quickly and engage the enemy using long range, direct fire weapons. Their ability to deploy rapidly is limited and are best for developed theaters.[13] These divisions are not pure (i.e., their maneuver units are not entirely armor or mechanized infantry). An armored division has six armor battalions and four mechanized infantry battalions. A mechanized infantry division has five armored battalions and five mechanized infantry battalions. See Figure 2 for a typical heavy division organization.[14] (FM 24-1, 1985, p. 1-6)

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[13] FM 100-15, 1989, p. 2-4.

[14] See Appendix B for symbology. (FM 101-5-1, October 1985)

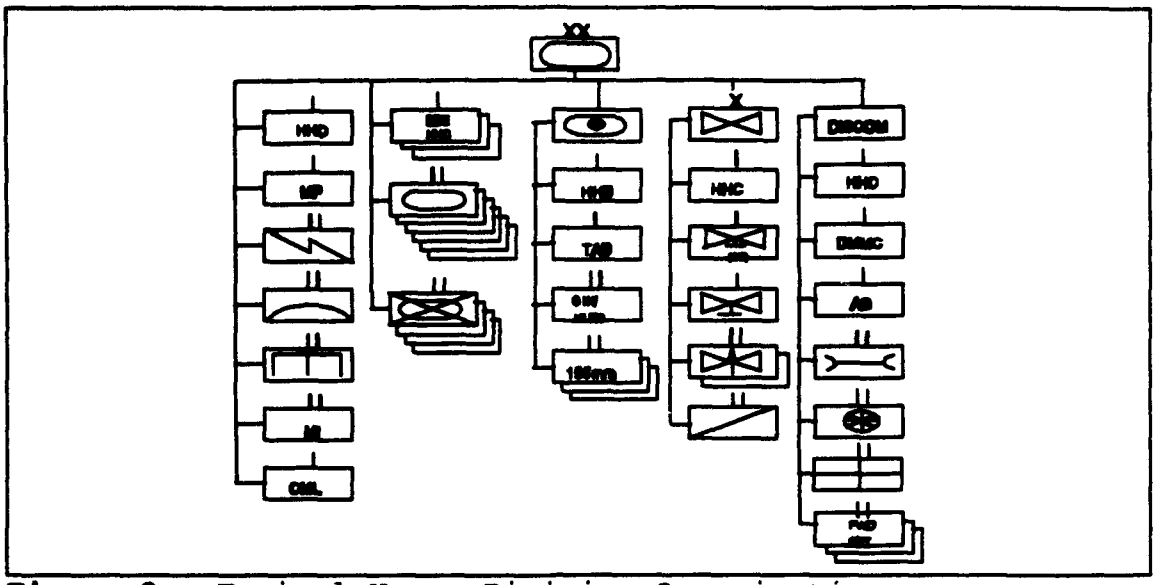

Figure 2. Typical Heavy Division Organization

(4) Airborne Division. The airborne division is designed for rapid deployment. It is organized, equipped, and trained to conduct parachute assaults. They are dependent on the Air Force for airlift, Close Air Support (CAS), and resupply. This division type is well suited for power projection in contingency operations and in situations calling for early buildup of combat forces. This employment strategy was observed during Operation Desert Shield. The airborne division provides limited combat power early and will require reinforcement to sustain and continue operations. (FM 100-15, 1989, p.2-4)

(5) Air assault Division. The air assault division is designed to conduct rapid tempo tactical operations over extended ranges. Organic rotor airlift and attack craft enable the division to project significant combat power. The agility of this division to concentrate, disperse, and redeploy its forces make it a highly responsive mobile reserve. (FM 100-15, 1989, p. 2-4)

c. Brigade

The mission of the brigade is to close with and destroy enemy forces using its mobility, firepower, and shock effect. Brigades do not act independently but as part of a division or corps. There are two types of brigades. They are divisional and separate. (FM 71-3, 1988, pp. 1-1, 1-5)

(1) Divisional Brigade. Divisional brigades are subordinate to a division. The only permanently assigned unit to a brigade is its Headquarters and Headquarters Company (HHC). The HHC provides direction and C2 over units assigned to, attached to, or supporting the brigade. The division commander attaches maneuver battalions to the brigade based on the situation and mission requirements. A brigade can control two to five battalions. Normally during peacetime, a brigade maintains a habitual relationship over three battalions. During combined operations (the norm) additional units are tasked to provide Direct Support (DS). Brigade DS is ordinarily comprised of a FA battalion, an ADA battery, an

engineer company, a signal platoon, a MP platoon, combat Intelligence and Electronic Warfare (IEW) elements, a Tactical Air Control Party (TACP), and a DISCOM Forward Support Battalion (FSB). A brigade with all attached and DS units is commonly referred to as a Brigade Task Force. (FM 71-3, 1988, pp.1-5,1-6)

(2) Separate Brigade. Separate Brigades conduct operations under corps command and are organized to provide their own support. They are a stand alone combined arms force with organic assets. These assets include: HHC, MP, chemical, signal and ADA elements; maneuver battalions; armored cavalry troop; FA battalion; engineer company; MI company; and FSB. Additional combat, CS, and CSS units may be attached. A separate brigade may be attached to a division but is usually controlled by corps. (FM 71-3, 1988, pp. 1-6)

d. Battalion

The battalion baseline is three line companies and one headquarters (HQ) company. A pure battalion (infantry or armor) is composed of three identical line companies and the HQ company. Battalions, like brigades, can be task organized to improve their capabilities. Task organization is directed by the brigade commander based on his/her estimate of the situation. A task organized battalion is called a Battalion Task Force. (FM 71-1, p. 1-2)

- **Company**

The company baseline consists of three line platoons and a company HQ (platoon sized). In a pure battalion, the battalion commander may direct cross-attachment of platoons/sections depending on mission requirements (usually to exploit or reinforce). Companies in a Battalion Task Force can be task organized into Company Teams. The task force commander may cross-attach platoons to form one or more Company Teams. Company Team organization is based on his/her estimate of the situation. (FM 71-1, p. 1-6)

B. ARMY COMMUNICATIONS ARCHITECTURE, AN OVERVIEW

The Army Communications Architecture is an ongoing and evolving entity. Changing tactics and technological advancements are driving this evolution. For millennia tactical forces were concentrated enough to be directed either visually or vocally by their commanders. Dispersion of forces has increased exponentially with the increase in range and lethality of weapons and the availability of information technologies. Tactics (i.e., doctrine) to combat new weapons systems have altered accordingly. The challenge to communications engineers is to develop architectures and systems which provide the necessary support to the warrior on the battlefield.

The current Army doctrine is called Air-Land Battle Doctrine. The Air-Land Battle doctrinal view of the

battlefield is nonlinear. A commander must be able to see deep into the enemy's rear and expeditiously employ combined forces to destroy him. The key to a commander's success is his ability to integrate and coordinate the combined force. The current Army communications architecture is designed to support the commander in prosecuting Air-Land Battle operations. (FM 24-1, pp. 1-1,1-2)

1. Battlefield Functional Areas (BFA's)

To support the Air-Land Battle doctrine the Army has identified five groups or functional areas of users that must be supported by the communications architecture. These five groups are called Battlefield Functional Areas (BFA's). The BFA's are Maneuver[15], Combat Service support (CSS)[16], Fire Support (FS)[17], Air Defense Artillery (ADA), and Intelligence/ Electronic Warfare (IEW)[18].

2. Communications Triad

To support the BFA's the Army communications architecture appears as a triad. The triad consists of the Area Common User System (ACUS), the Army Data Distribution System (ADDS), and the Combat Network Radio (CNR). See Figure 3.

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[15] Encompasses maneuver units (AR, INF, AV).

[16] Logistics community.

[17] Field artillery community.

[18] Military Intelligence community.

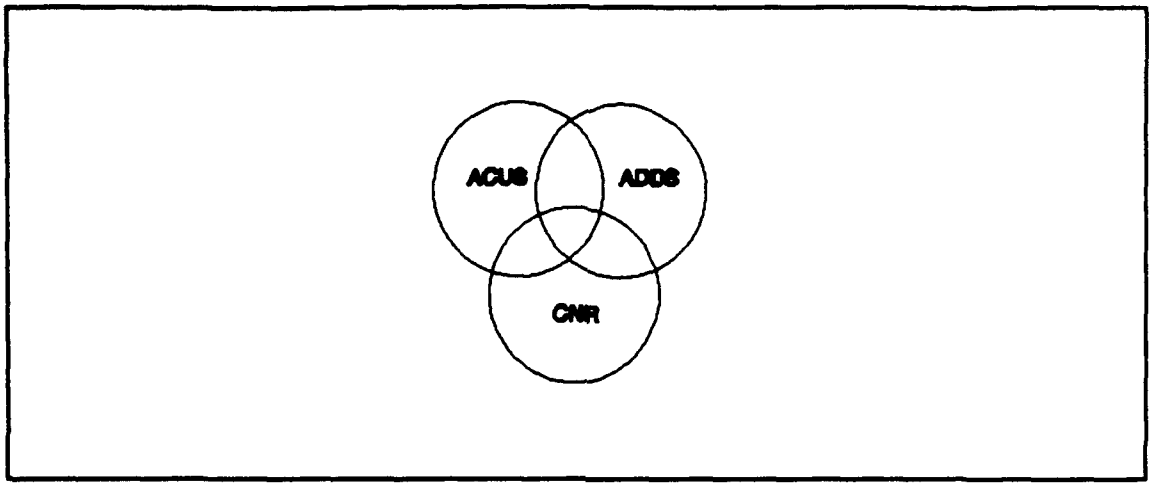

Figure 3. The Triad

a. Area Common User Circuit (ACUS)

The ACUS is analogous to a tactical, military Bell Telephone System. Under the umbrella of ACUS are the systems and equipment that establish the backbone switching and telephone system. The roots of ACUS are traceable to the simple land line telephone systems of World War I. The concept of the ACUS has remained constant. The technologies supporting it continue to evolve to keep pace with commanders on a spatial expanded and temporal contracted battlefield. The Army Mobile Subscriber Equipment (MSE) is the current ACUS.

b. Army Data Distribution System (ADDS)

ADDS came into being with the advent of digital data. The pace of battle and reduced force levels have made timely information gathering and dissemination critical. To support near real-time sensor and targeting data distribution

the Army has developed, and continues to improve, Battlefield Automated Systems (BASs, also called Battlefield Operating Systems, BOSs). Examples of BASs are: Maneuver Control System (MCS), Forward Area Air Defense System (FAADS), Advanced Field Artillery Tactical Data System (AFATDS), and the All Source Analysis System (ASAS). Interface of the BASs is a challenge. The Enhanced Position Location Reporting System (EPLRS) is a system currently undergoing trials as the standardized workhorse for BAS data transfer. (Sciomacco)

c. Combat Net Radio (CNR)

CNR is the tactical voice (FM or AM) network. The primary function of CNR is to provide the maneuver commander real time command and control (C2) of his forces. As with all radiating systems, Direction Finding (DF) and jamming are the CNR's weaknesses. To overcome these shortfalls two trends have emerged. First, tactical voice radio emissions at the brigade level and above are being reduced. Brigade/Division Tactical Operation Centers (TOCs) are relatively static and can therefore rely more on fixed communications (i.e., ACUS and ADDS) for C2I. Units below the brigade level habitually displace often. Movement, Emission Control (EMCON), and proper Radio Telephone Operating (RTO) procedures reduce the effectiveness of enemy intercept, jamming, and DF. Secondly, technological advancements (frequency hopping, spread spectrum, etc.) have improved radio performance in combating

enemy Electronic Counter Measures (ECM). To capitalize on these advancements, the Army has fielded the Single Channel Ground and Airborne Radio System (SINCGARS) as a replacement for existing UHF radio sets.

3. "Sigma Star"

The cumulative representation of the communications triad in concert with the Battlefield Functional Areas (BFAs) is called the "Sigma Star." Sigma is used in deference to the mathematical use of the greek letter S to indicate sums. The Sigma Star is depicted in Figure 4.

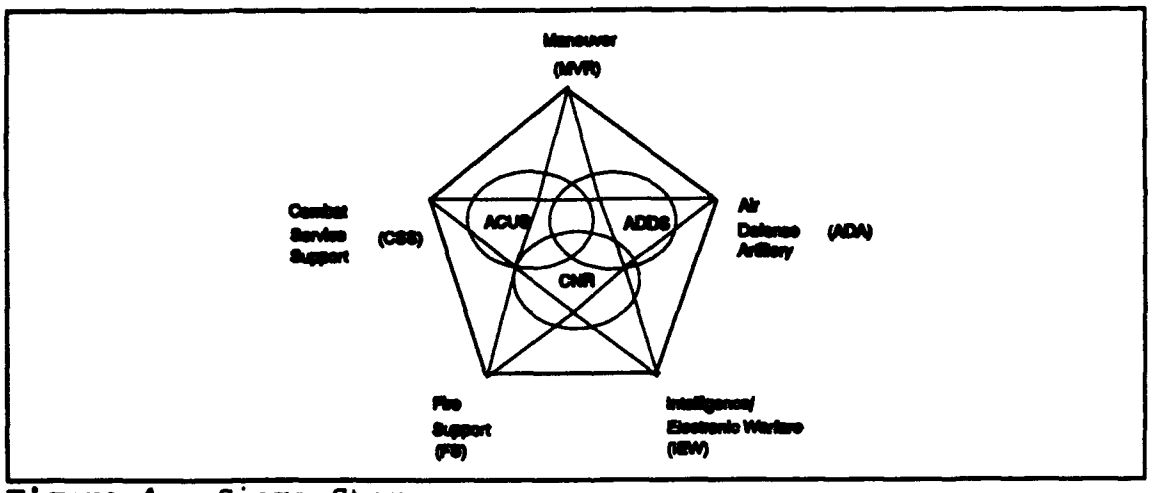

Figure 4. Sigma Star

It is seen that the three systems of the communications architecture overlap each other and the links between BFAs. The Sigma Star exists at all echelons with combined forces. This is the heart of Army communications.

In this configuration the BFAs share data over one or more of the triad links. In the past, CNR has been the communications link workhorse. Shared information creates a synergistic effect that allows a commander to make sound decisions. Sigma Star functionality provides an avenue for information synergism which is the key to success on the Air-Land Battlefield.

4. Army Tactical Command and Control System (ATCCS)

The employment and integration of the Sigma Star from corps through brigade is called the Army Tactical Command and Control System (ATCCS) (see Figure 5).

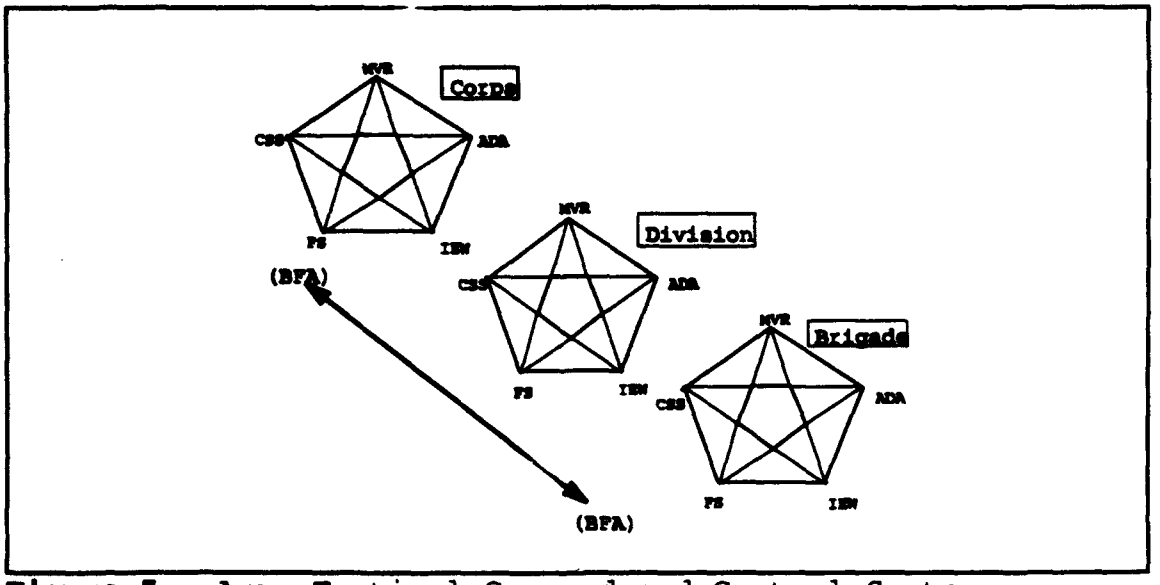

Figure 5. Army Tactical Command and Control System

Integration of the Sigma Stars occur through either MSE gateways or like BFA's operating systems. Similar systems

and procedures exist within like BFAs at each echelon within the ATCCS. Passing information vertically between like BFAs is easy however, it creates the stove pipe effect. In the past horizontal communications were achieved using voice radios. This approach is too slow and unreliable. The hurdle for the Army is fusing and disseminating information between BFA's.

5. Army Communications Architecture in Transition.

Reduction of forces and diversified missions are compelling the services to increase unit lethality. A unit must acquire, identify, track, engage, and destroy an enemy efficiently. Gone are the days of deploying field armies that prosecute protracted campaigns. Service doctrine is maturing accordingly. As stated in the *National Military Strategy of the United States* (1992), an essential element of our national military strategy is the ability to overwhelm our adversaries and terminate conflicts swiftly (p. 10). The existing army communications architecture is technologically constrained and can not effectively fuse and rapidly disseminate data in support of the National Military Strategy.[19] Ergo, the communications architecture is in transition.

One new vision for the Army's C4 programs is called the "Enterprise Strategy". This strategy is the brainchild of Lieutenant General Peter A. Kind, USA, Director of Information Systems for Command, Control, Communications, and Computers

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[19] EPLRS LRIP, Feb 1993, p. 1-0.

(C4), Office of the Secretary of the Army. LTG Kind describes the "Enterprise Strategy" as:

> ...an architecture that will support force projection, from CONUS [continental U.S.] through the tactical area [in a regional theater], with no boundaries. Enterprise is an overall road map for the modernization of the whole information management area... it takes the equipment we have now and projects what we're going to have coming in each area, what our goals are, and how we want to implement them. It encompasses the whole range of information management services and includes CONUS through the tactical forces. So it says that we provide whatever service the commander or his staff needs anywhere on the globe and get information to wherever it is needed. (Goodman, June 1993, p. 46)

The Enterprise Strategy envisions one architecture that goes well beyond the individual tactical systems (ACUS, ADDS, CNR).[20] The base functions of the triad will continue to be required on the battlefield. There will always be a need for a communications backbone, combat voice, and data distribution. However, the functions can no longer be viewed as separate entities with minimum overlap (see Figure 3). The functions must operate as one synergistic, seamless system. The communications architecture from the triad through the ATCCS must function as a veritable tactical "information highway."

Another vision (by Hughes Aircraft Company) of the future architecture is seen in Figure 6. This architecture

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[20] Browning, E-MAIL, 14 March 1994.

objective, like the Enterprise Strategy, is to integrate information. Unlike the Enterprise Strategy, it is focused on the tactical level only. (EPLRS LRIP, Feb 1993, p. 1-3)

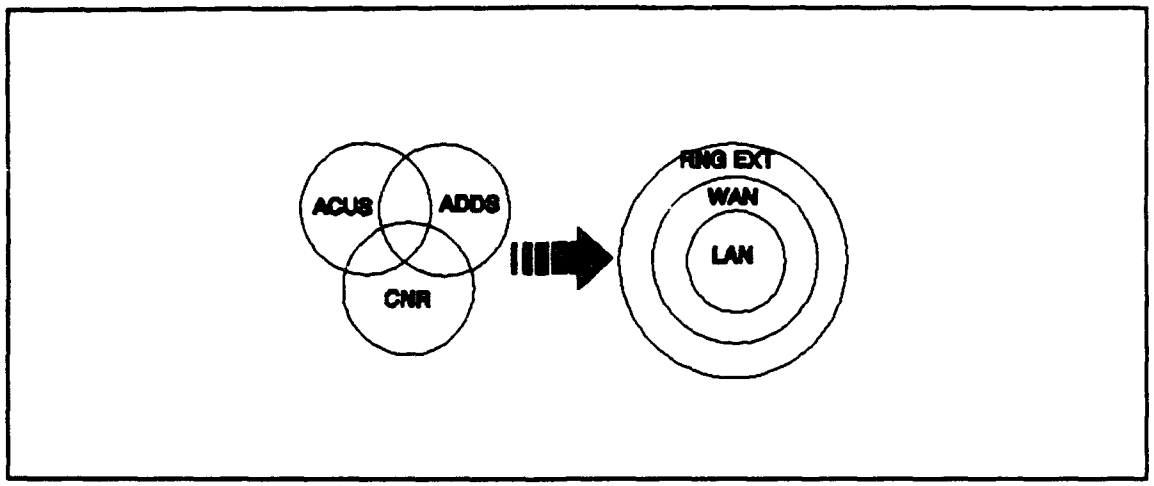

Figure 6. Triad in Transition

This vision proposes three levels. These levels are Local Area Network (LAN), Wide Area Network (WAN) and a Range Extension (RNG EXT). The LAN is designed to support a division sized element, WAN for corps, and the RNG EXT for gateways to echelons above corps (EAC) and distanced units.

While these two proposed visions are similar in nature, the Enterprise Strategy is a depth and breadth solution to the future Army Communications Architecture which is receiving support. The executive or top-level design of the "Enterprise Strategy" has been published. The implementation

plan has not.[21] Exactly what the Army's new communications architecture will be remains to be seen. It is apparent that the tenet of this architecture is that it be single and seamless. Systems that do not meet, or cannot be adapted to this architecture will not be supported in the top level review process. (Browning, E-Mail, 14 March 1994)

[21] Goodman, Jun 1993, p. 46.

III. ARMY BACKBONE COMMUNICATIONS

The Army backbone communications system is established using Mobile Subscriber Equipment (MSE). MSE is a mobile, militarized, long-distance communications system designed to keep pace on the Air-Land Battlefield. The previous backbone system was fielded under the auspices of the Tri-Service Tactical Communication (TRI-TAC) concept.

TRI-TAC was the first generation of communications equipment designed to support modern combat forces. As stated in DOD Directive 5148.7, the program objective was "to lay the foundation for maximum effectiveness and economy in the future development, programming, and acquisition of joint communications equipment for tactical forces of the U.S. Services." TRI-TAC met this objective and dovetailed with the Army's shift in doctrine from the Active Defense to Air-Land Battle. TRI-TAC was a personnel, equipment, and cable intensive system. Although TRI-TAC was too cumbersome for corps level and below, its switches remain the workhorse for EAC, joint, and coalition interface. In its infancy, the system was Pulse Code Modulated (PCM) supporting analog communications. It was a preliminary step in supporting modern combat communications requirements however, the system's size, weight and marginal circuit quality doomed it to failure as the tactical level system. (Bingham, pp. 1-20)

Acquisition of a modern communications system that could keep pace on the battlefield was paramount to the Army. The study of equipment to support a mobile subscriber began as early as June 1955. The project however was not pursued in earnest until the late 1970's. A special task force to shepherd MSE into development was established on 14 December 1977. MSE as is manifest in the inventory today was developed by General Telephone and Electronics (GTE) in conjunction with the French Reseau Integre de Transmissions Automatique (RITA). The incorporation of technological advancements reduced the size and weight of equipment, and automated numerous functions. This mobile communications system with reduced personnel requirements supports the tactical commander. (Bingham, pp. 1-23)

A. MOBILE SUBSCRIBER SYSTEM OVERVIEW

Mobile Subscriber Equipment is a secure, flexible, area grid communications system that services both mobile and wire subscribers. Designed for the corps and below it is a digital system that is capable of transmitting both voice and data. It has gateway interfaces for interoperability with echelons above corps, joint and NATO nations. Two unique characteristics of the MSE system are fixed subscriber telephone numbers and flood search routing. A user's telephone number remains the same regardless of their location on the battlefield. Flood search routing enables calls to be routed

automatically over an optimum route on a call-by call basis. This technique negates the need for pre-stored routing tables to make call connections. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. A1-5, A1-11, p. A4-10)

1. MSE Functional Areas

The equipment configuration of MSE forms five functional areas: area coverage, wire subscriber access, mobile subscriber access, subscriber terminals, and system control. This functional representation is presented in Figure 7. (Operational and Organizational Plan for Mobile Subscriber Equipment (MSE) System, 1986, p. 3-6)

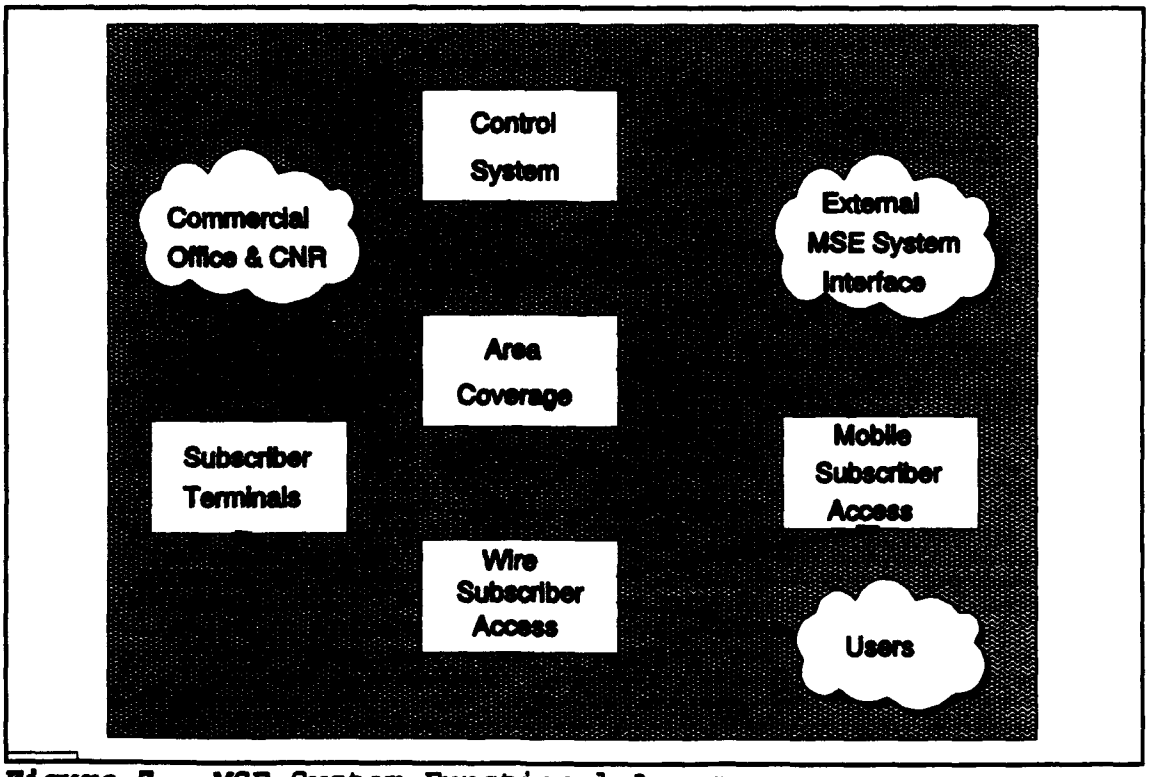

Figure 7. MSE System Functional Areas

2. MSE Architecture

To integrate the five functional areas, MSE uses a tri-level architecture: the grid system, the extension system, and users. The grid system provides the backbone (major switch to major switch) for inter-connectivity (i.e., area coverage) and network management (system control) throughout the MSE area. The extension system supports the wire subscriber access from small switches located at the users' Command Post (CP) into the backbone system. The users portion of the architecture encompasses the user Installed, Owned, operated and Maintained (IOM) subscriber terminals and mobile subscriber access. The relationship between the MSE architecture and functional areas is depicted in Figure 8. (Schuam, pp. 6-22, Fall 1984)

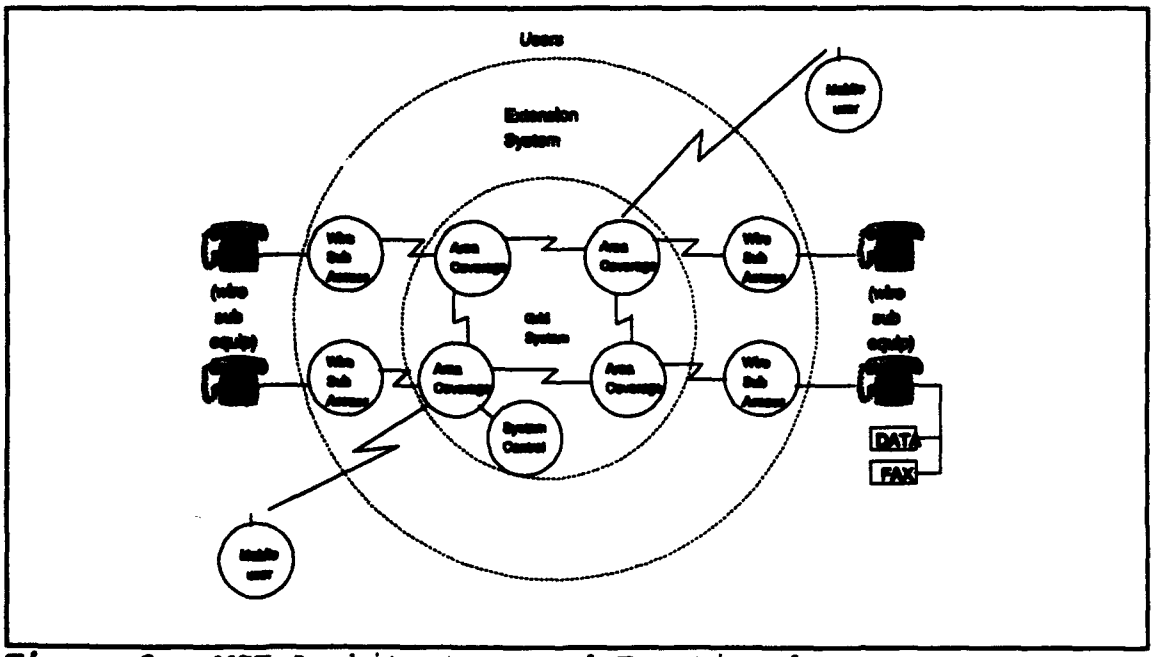

Figure 8. MSE Architecture and Functional Area Relationship

B. DEPLOYMENT CONCEPT

The MSE system at the corps level is designed to support communications for up to five divisions. The corps area of responsibility during battle is approximately 37,500 square kilometers, or 150 km x 250 km. The system is self organizing and provides secure voice and data communications on an automatic, discrete address, fixed directory basis using a form of flood search. Links between communications sites (i.e., switching) is normally accomplished through the use of radio "shots". The radio shots are UHF Line of Sight (LOS). If distance prevents the use of single leg LOS, relays (if plausible) or satellites are employed. (Bingham, Appendix A, p. 1)

1. MSE Core Unit, the Signal Battalion

The basic building block for MSE communications is the signal battalion. Each division has an organic signal battalion and the corps signal brigade has three signal battalions. A signal battalion has four companies. These companies are Headquarters and Headquarters Company (HHC), A, B, and C. For ease of understanding, the following description is focused on the division signal battalion.

a. Headquarters and Headquarters Company (HHC)

The primary mission of the HHC is to provide support to the line companies (A B, and C). The major sections of HHC are command, Operations and Intelligence (OP/INTEL),

administrative and maintenance (motor, CE, COMSEC). The OP/INTEL section (S3) is responsible for the planning, installation and management of the MSE communications system within the division's area. System control is exercised through the use of a System Control Center (SCC) assemblage. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, p. A2-9)

b. Area Signal Company

Alpha and Bravo companies are called Area Signal Companies and are identical. Their mission is to establish the backbone system and provide switching assemblages to CPs. Each company has approximately 160 personnel divided into three platoons: HQ, and two nodal (first and second). The HQ platoon supports company operations and consists of an administrative section and a motor maintenance section. The nodal platoons are identical. Each of these platoons has one Node (major switching center), four Small Extension Nodes (SENs, small switch) and two Radio Access Units (RAUs, one local at the node center (NC) and one remote (RRAU)). (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. A2-10, A2-11)

c. Signal Support Company

Charlie company, called the Signal Support Company, is responsible for establishing a Large Extension Node (LEN, large switch). It has approximately 55 personnel

and is divided into two platoons: Company Headquarters and Support Platoon. The company headquarters is functionally the same as the area signal companies. The support platoon is equipped with a LEN and FM retransmission section. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. A2-12, A2-13)

2. The Grid System

The grid system portion of MSE architecture encompasses the functional areas of area system and system control. Establishing the functionality of the area system is accomplished by positioning and inter-connecting node centers (NCs). System control is done through the SCC.

a. Area System

To establish NC positioning criteria and areas of responsibility the corps area is divided into two coverage regions, front and rear. The front area extends from the Forward Line of Troops (FLOT) to the rear of the divisional sector. The rear area is from the division rear boundary to the corps rear boundary. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. 2-4, 2-7)

(1) Corps Forward Area. Within the corps forward area, each division is responsible for establishing their portion of the MSE backbone system and tying-in to adjacent

forces (left to right).[22] The division's signal battalion is used to accomplish this task. Each signal battalion establishes and links four Nodes within its perspective division's boundaries. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. A2-4, A2-7)

(2) Corps Rear Area. The corps rear area is supported exclusively by the corps signal brigade. The signal brigade provides 22 Nodes, in addition to the subordinate divisional assets, to complete the grid system. The responsibility of establishing connectivity to the division backbones rests with the signal brigade (higher to lower).

b. NC Connectivity in Support of the Area System

The primary objective of the node center is to provide area coverage. NC capabilities include: tandem digital switching; management and recommendations for subscriber location; primary gateway access; access for MSRT subscribers; interface for SCC; access for 24 local wire subscribers; and access for one LAN. Each node center is composed of a Node Center Switch (NCS, AN/TTC-47), Nodal Management Facility (NMF, AN/TSQ-154), two RAUs (local and remote, AN/TRC-191), and four LOS (AN/TRC-190(V3)) assemblages. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. A3-19, A3-20)

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[22] The rules of thumb for responsibility are: supporting to supported; higher to lower; and left to right. See Joint Pub 6-0, p. I-4.

(1) Node Center Switch (NCS), AN/TTC-47. The primary function of the switch is to route calls between switches by the flood search technique. It is the principal network interface for RAU, SEN, LEN, NATO Analog Interface (NAI), and Digital NATO Interface (DNI). The NCS is comprised of two HMMWV shelter mounted assemblages (switching shelter (ON-306/TTC-47) and operations shelter (OL-413/TTC-47)). Power is provided by one PU-753, 10 kilowatt (kw) trailer mounted generator. The two assemblages form the AN/TTC-47 switching and operations facility. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. B1-7)

The ON-306/TTC-47 (switching shelter) is often referred to as the COMSEC shelter. It is unmanned and contains the trunk encryption devices and time division switching group.

The OL-413/TTC-47 (operations shelter) is used for manual operator service. Its major components are: switching processor; downsize routing subsystem; digital computer; and status display and keyboard. The operator activities (after system initialization) are similar to that of a civilian telephone switch operator. Their primary responsibility is to provide assistance to subscribers. This is done through the use of the Call Service Position (CSP). NC switch capacity is indicted in Table II. (Student's Training Course Guide for Nodal Operations Management Course,Dec 1991, pp. B1-10, B1-31)

Table II. NC SWITCH CAPACITY

24 Local Wire Subscribers
648 Digital Terminations
8 Trunk Terminations
10 Digital In-band Signaling Buffers
16 Digital Transmission Groups
20 Digital Receivers
24 Digital Loops (used by sig spt)
4 Conference Bridge Units
Interface for STANAG 5040 (NAI)
Packet Switch Capacity:
5 Trunks to Adjacent NC/LEN PS
5 Trunks to SEN PS
1 LAN Interface

(2) Node Management Facility (NMF), AN/TSQ-154. The TSQ-154 is deployed in support of both NCs and LENs. It provides the equipment and space required by the site OIC to manage the resources of the NC or LEN and connected elements. The management facility consists of a shelter mounted HMMWV and is equipped with an intercom, Electroluminescent Display Terminal (EDT) and keyboard, and Digital Non-secure Voice Terminal (DNVT). (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. B1-39)

(3) AN/TRC-190(V3). Connectivity between NCs is accomplished using the TRC-190(V3). The NC has four TRC-190(V3)s. All LOS assemblages consist of a HMMWV mounted shelter with a PU-751 (5 kw) trailer mounted generator. The TRC-190 employs a highly directional antenna for point to point communications (LOS to LOS). Each TRC-190(V3) contains four Ultra High Frequency (UHF) line of sight (LOS) radio sets (AN/GRC-226). Up to three radios may be active at one time (the fourth is a spare). There are two models of the GRC-226. The RT-1537/GRC-226(V) is a band I radio operating from 225-400 MHz with 10 watts of power output. The RT-1538/GRC-226(V) is a band III radio operating from 1,350 to 1,850 MHz with 5 watts of power output. These radios provide multichannel circuits in support of the MSE system. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. C2-13, C2-50)

For network survivability a NC is typically linked to three other nodes. This leaves nine radio stacks available at a node to accommodate SEN, LEN, RRAU, and NATO interfaces. Figure 9 depicts a fully established NC. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. B1-5)

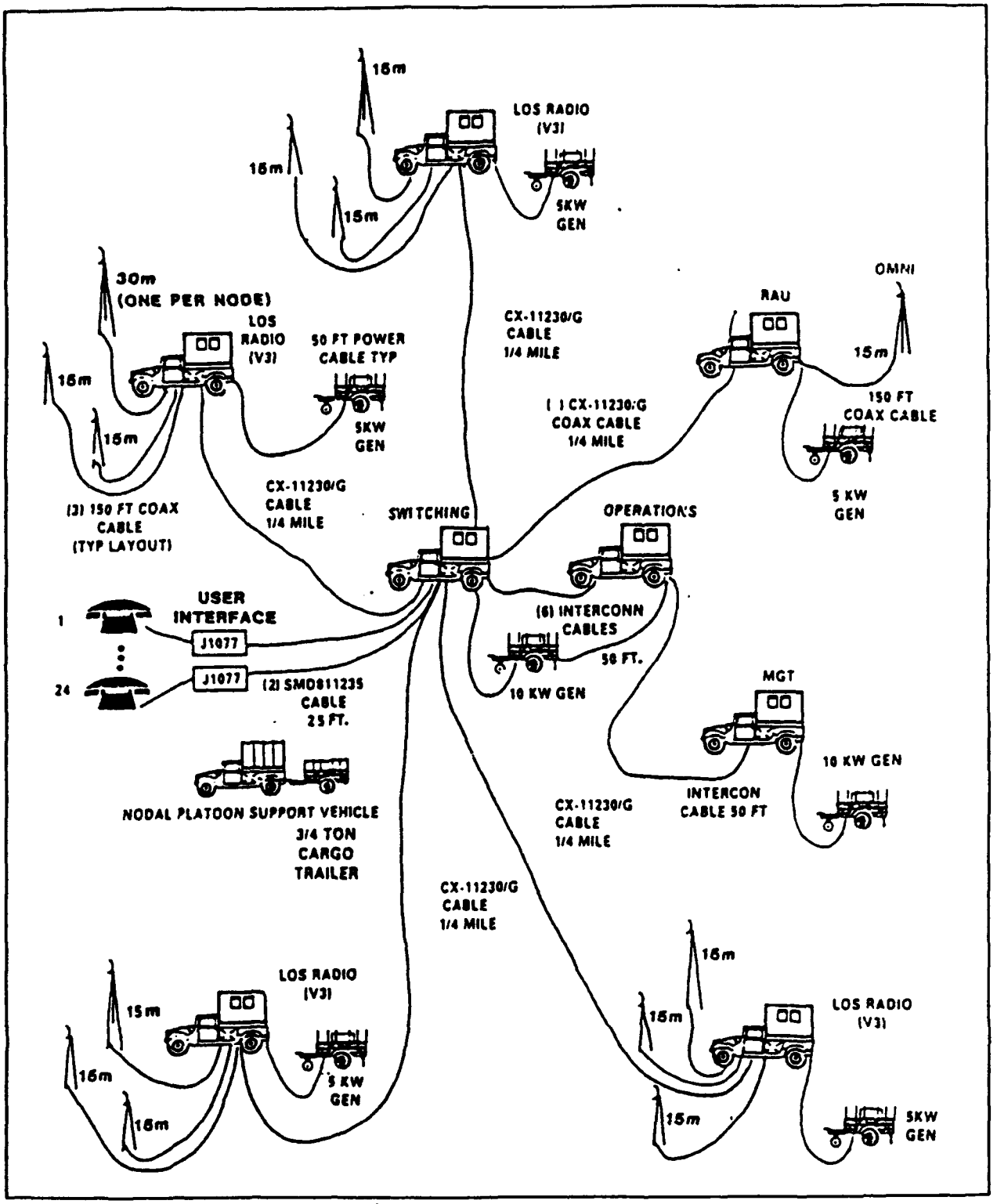

Figure 9. Node Center Site

c. System Control

System control is accomplished using the System Control Center (SCC) assemblage. The SCC is responsible for: network management; frequency management (RAU, MSRT, and LOS); terrain analysis (for LOS path profiling); system activation and reconfiguration; equipment and personnel status. Each division has one organic SCC (OP/INTEL section of HHC, signal battalion). The corps has two SCCs (located in the OP/INTEL section of HHC, signal brigade). The division SCC is comprised of two HMMWV mounted shelters (technical and management/planning) and one PU-753 (10 kw) trailer mounted generator. A corps SCC has an additional management/planning shelter and PU-751 (5 kw) generator.

Each division is responsible for system control within their sector. The division SCC is active at all times. The corps SCC is responsible for overall system management. Under static conditions, one corps SCC is capable of managing the system. The second corps SCC may remain in reserve or, under more dynamic circumstances, be used to control selected division teams. The SCC is not stand alone. It relies on established communications links for information inputs and is therefore co-located with a NC or LEN. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. E1-3, E1-10)

d. Grid System in Toto

As stated earlier the grid system encompasses the functionalities of area coverage and system control. Area coverage is established with the radio inter-connectivity of the nodal backbone. This connectivity provides the links over which information is transmitted. MSE at the corps level is designed and equipped for the employment of up to 42 nodes. System control of this behemoth is directed from the SCC. While each division possesses a SCC for internal system management, overall system management is the responsibility of the corps. The grid system in toto appears as depicted in Figure 10 (triangles indicate Nodes, circles indicate SCC). (Mobile Subscriber Equipment (MSE) Architecture, 1988, p. 1-6)

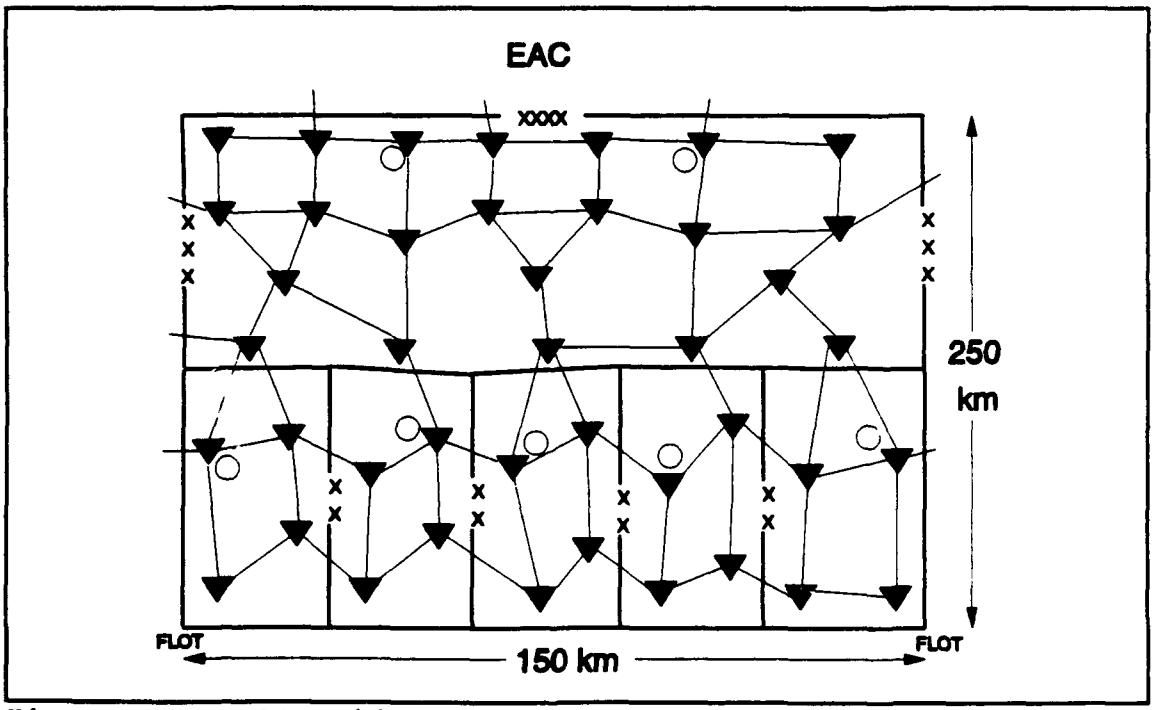

Figure 10. MSE Grid System

3. The Extension System

The extension system portion of the MSE architecture encompasses the wire subscriber access functional area. This area entails all communications switching and transmission equipment at all CPs (e.g., Tactical Operations Center (TOC) and Tactical Command Post (TAC)). This area also includes access for non-MSE subscribers through Radio to Wire Interface (RWI). The two types of extension switches available are the Large Extension Switch (LEN) and the Small Extension Switch (SEN). (Project Manager, Mobile Subscriber Equipment, 1 August 1986, pp. 1-6)

a. Large Extension Node (LEN)

The mission of the LEN is to provide communications support to large command posts (e.g., COSCOM, DISCOM). LEN capabilities include: network access switching; local service switch; CNR access (KY-90 location dependent); commercial office access; and packet switch support. The LEN is capable of supporting up to 176 local subscribers. Each LEN is composed of a Large Extension Node Switch (LENS, AN/TTC-46), Node Management Facility (NMF, AN/TSQ-154), one RAU (local, AN/TRC-191), and one LOS (AN/TRC-190(V4)) assemblage. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. B1-40, B1-44)

(1) Large Extension Node Switch (LENS, TTC-46). The primary function of the LENS is technically the same as the NCS but with some quantity and interface differences. The LENS serves as a network access switch and supports local switching requirements. Its primary interfaces are to commercial office (local commercial telephone system) and packet switch subscribers (via TYC-20). The LENS is comprised of two HMMWV shelter mounted assemblages (switching shelter (ON-305/TTC-46) and operations shelter (OL-412/TTC-46)). Power is provided by one PU-753 (10 kw) trailer mounted generator. The two assemblages form the AN/TTC-46 switching and operations facility. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. B1-40, B1-44)

The LENS provides wire termination for up to 176 local subscribers through the use of junction boxes (J-1077) and Remote Multiplexer Combiners (RMC, TD-1234). The RMC's support up to 80 subscribers and the junction boxes accommodate the remaining 96. Table III details the difference in LEN versus NC switch capacity. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. B2-38, B2-44)

Table III. LEN VERSUS NC SWITCH CAPACITY

	LEN	NC
Digital Terminations	648	648
Trunk Signaling Buffers	4	8
Digital In-band Signaling Buffers	4	10
Digital Transmission Groups	8	16
Digital receivers	20	20
Digital Loops	84	24
Analog Loops for Commercial Interface	4	0
Conference Bridge Units	4	4
Packet Switch Hosts	7	0

(2) Node Management Facility (NMF), AN/TSQ-154. See Chapter III, section 2.b.(2).

(3) AN/TRC-190(V4). Connectivity from the LEN to the NC's is accomplished using the TRC-190(V4). The LEN has one TRC-190(V4). Assemblage description for the V4 is the same as the TRC-190(V3) (see Chapter III, section 2.b.(3)) with the exception of the number of radios. The TRC-190(V4) contains only two UHF LOS radio sets (AN/GRC-226). Radio capabilities description is the same as presented for the V3. For network survivability a LEN is linked to two NCs. A deployed LEN is depicted in Figure 11. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. C2-44, C2-45)

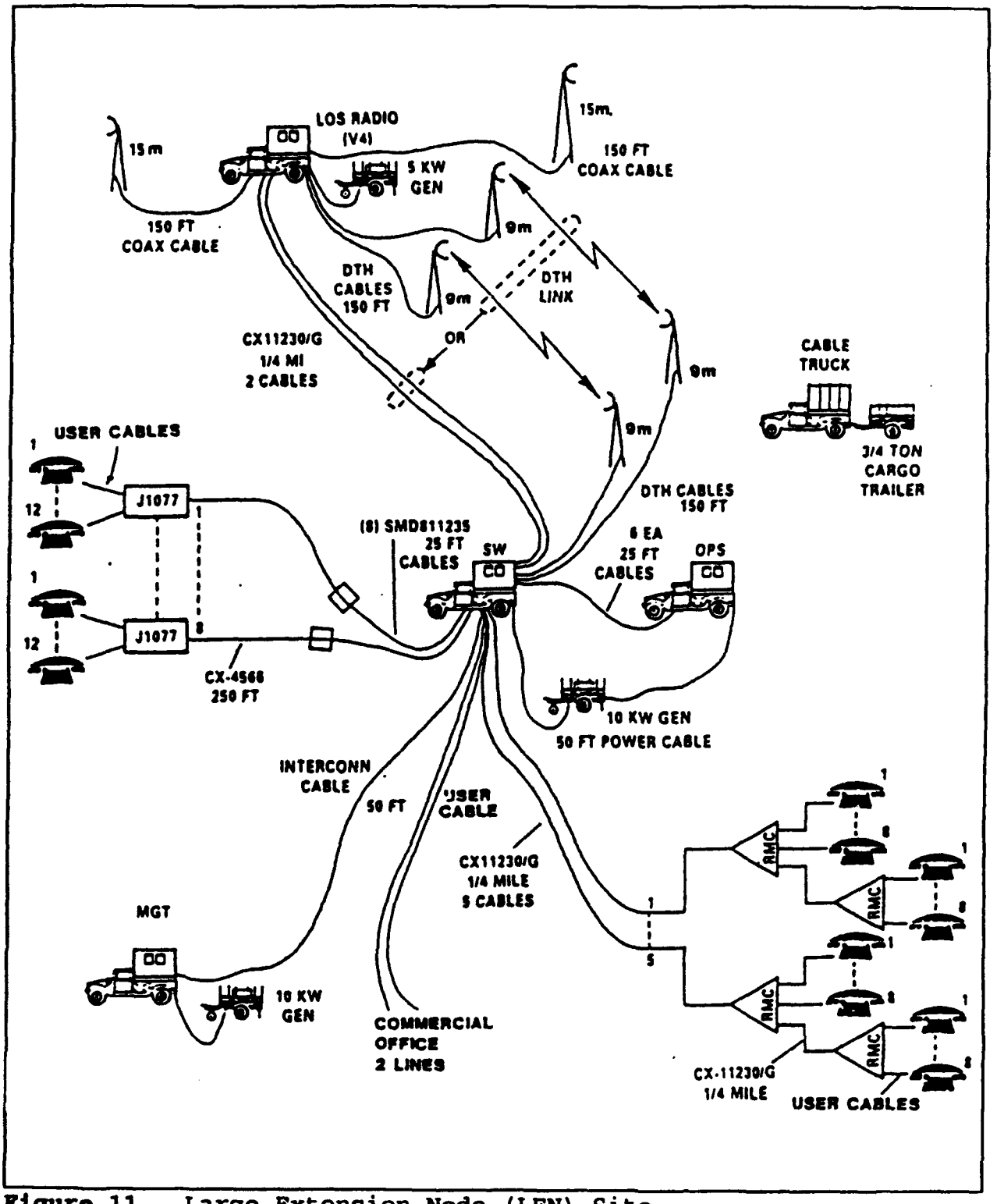

Figure 11. Large Extension Node (LEN) Site

b. Small Extension Node (SEN)

There are two types of SENs: SEN V1, and SEN V2. The mission of the SEN is to provide network access and local switching. The SEN is intended for small CPs (brigade, separate battalions, etc.). Assemblage composition of both SEN variations is identical. The difference between the SENs is in switching capacity. The SEN consists of two HMMWV mounted shelters (switch and LOS).

(1) SEN Switch (AN/TTC-48 (V1&V2)). The primary component of the TTC-48 is two automatic switchboards (SB-4303). The switchboards provide automatic routing of calls and allow for operator intercept/ assistance. The V1 and V2 support up to 26 and 41 subscribers respectively. Power to the TTC-48 is provided by a trailer mounted generator (PU-753, 10 kw). (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, p. A3-13, pp. B5-6, B5-31)

(2) AN/TRC-190(V1). LOS radio links are established between the SEN and NC via the TRC-190(V1). The assemblage description of the TRC-190(V1) is identical to the TRC-190(V3) and V4 except for the number of radios. The TRC-190(V1) has two radios (GRC-226, one is spare). A SEN V1 site is depicted in Figure 12. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. C2-22)

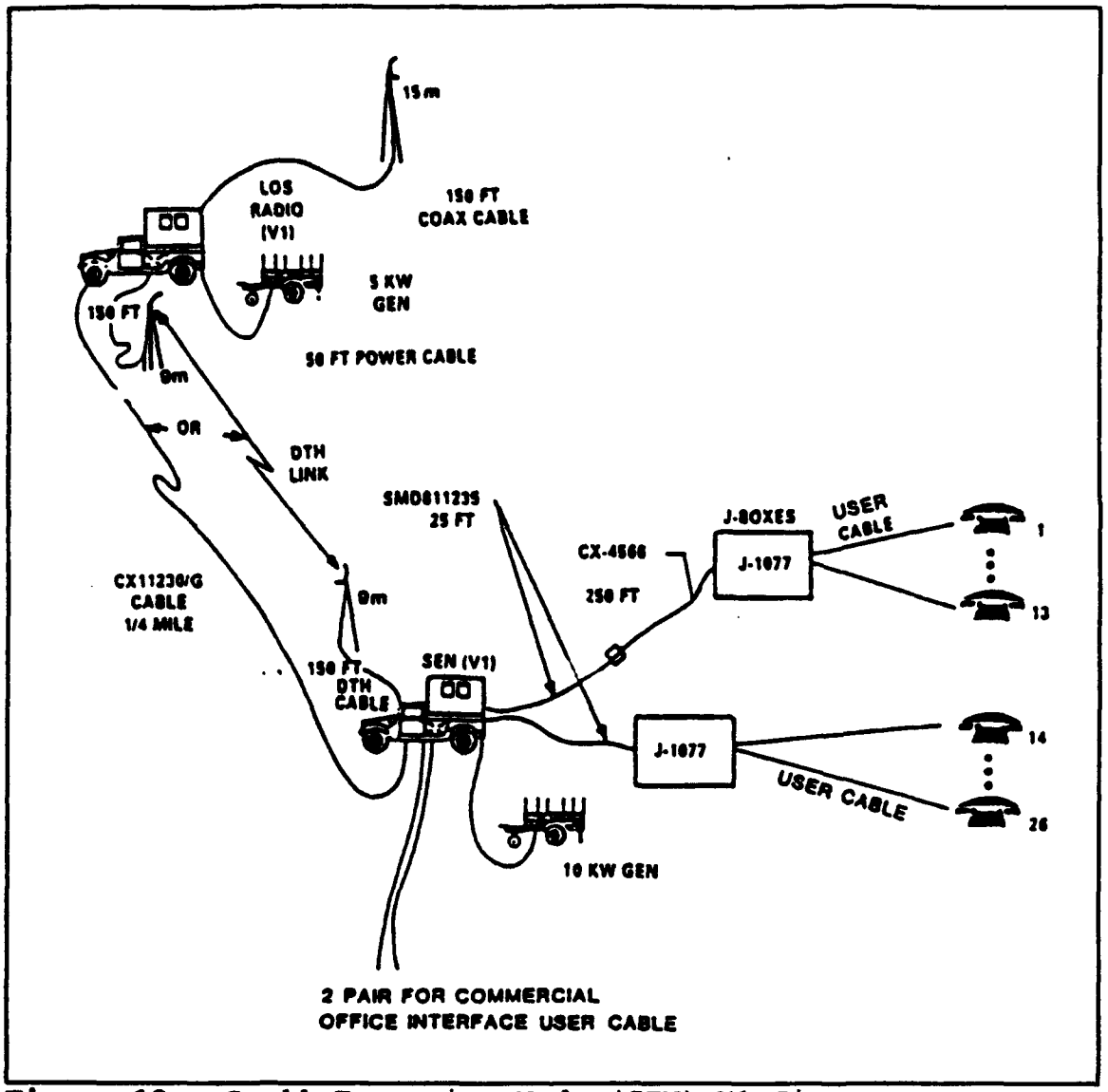

Figure 12. Small Extension Node (SEN) V1 Site

c. Radio to Wire Integration (RWI)

Radio to wire integration supports CNR FM users who wish to enter the MSE network. Each signal battalion has four KY-90s (sometimes referred to as a Network Radio

Interface (NRI) device) to accomplish integration. The KY-90s are connected to a VRC-12 series radio (e.g., RT-524) via an umbilical plug and wired (WD-1) into a switchboard (SB-4303). Operator interrupt is required to initiate RWI calls. The KY-90s are dispersed to provide optimum coverage of the division area. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. B5-18, B5-19)

4. Users

The third leg of the MSE architecture is users. System users access the MSE system through the use of land line devices or mobile subscriber equipment. The functionality of access is termed Subscriber Terminals and Mobile Subscriber Access respectively.

a. Subscriber Terminals

The three primary terminals available to a static user are the Digital Non-secure Voice Terminal (DNVT, TA-1035), Digital Tactical Facsimile (FAX, UXC-7) and Single Subscriber Terminal (SST). The DNVT is a four wire militarized push-button telephone. It operates off of an automated switchboard (connected by WD-1, J-1077, or RMC). The UXC-7 operates as a civilian FAX does. Dial-up support of FAX transmission is accomplished with the DNVT or Digital Subscriber Voice Terminal (DSVT). The SST is a data terminal that provides microprocessor functions for data/message handling, transmission and processing. The SST accesses the

MSE network through the data port on either the DNVT or DSVT. The SST enables data passed through the MSE system to interface with the AN/TYC-39 automatic message switch at EAC. The DNVT, FAX, and SST operate in the plain (the devices do not contain encryption modules). When communicating from a NC, LEN or SEN encryption of the signal occurs when processed for off site transmission. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, p. A3-4, p. A3-8)

b. Mobile Subscriber Access

Mobile subscriber access into the MSE system is accomplished using a Mobile Subscriber Radio Telephone Terminal (MSRT, VRC-97). The MSRT provides a means for mobile subscribers to communicate with secure voice or secure data (using FAX).

(1) Mobile Subscriber Radio Telephone Terminal. The MSRT provides a subscriber the means of discretely addressing switched common-users. Features of the MSRT include: internal COMSEC; reduces jamming and interference (by means of frequency hopping); execution of automatic affiliation, disaffiliation and reaffiliation. The MSRT consists of a Digital Subscriber Voice Terminal (DSVT, KY-68), Very High Frequency (VHF) radio (RT-1539) and installation kit. The MSRT is typically mounted in command Armored Personnel Carriers (e.g., M113, M577 or M2) and HMMWVs. There

is also a user stand-alone kit available. The DSVT is a securable militarized push-button mobile telephone. VHF transmission of the signal is accomplished by the RT-1539. (Student's Training Course Guide for Nodal Operations Management Course, Dec 1991, pp. A3-5, A3-7)

The RT-1539 is a full duplex communications unit. The signal from the RT-1539 accesses an available RT-1539 in a Radio Access Unit (RAU) and is linked into the network. The two frequency coverage modes of the radio are for CONUS and OCONUS. RAU and MSRT frequency coverage is depicted in Table IV.

Table IV. RAU & MSRT FREQUENCIES

	Lowband	Highband
CONUS	30-35 MHz	40-50 MHz
OCONUS	30-51 MHZ	59-88 MHz
RAU	RCV	XMIT
MSRT	XMIT	RCV

A fully deployed corps has approximately 1900 MSRTs in sector and 92 RAUs to support interface. There are two configurations for the RAU: local and remote. (MSE Primer for Small-Unit Leaders, 1988, p. 2-29, 2-31)

(2) Local Radio Access Unit (RAU, AN/TRC-191). Local radio access units (RAUs) are found at NCs and LENs. The mission of the RAU is to provide radio telephone interface

from mobile subscribers to the network. The RAU is composed of a HMMWV mounted shelter and a tailer mounted generator (PU-751, 5 kw). The major component of the shelter are eight RT-1539s. The radios are accessed by the mobile subscriber on a first-come-first-served basis. A RAU "footprint" for area coverage is a radius of approximately 15 kilometers.

(3) Remote Radio Access Unit (RRAU, AN/TRC-190). The RRAU is exactly the same as a RAU with the addition of a AN/TRC-191(V1) for LOS radio connectivity to a NC.

C. SYSTEM INTEROPERABILITY

MSE is designed to interface with other communications systems. These systems include TRI-TAC, commercial telephone, NATO, and CNR. (Mobile Subscriber Equipment (MSE Architecture, 1988, p. 1-16)

1. TRI-TAC Interface

MSE is fully compatible with TRI-TAC equipment to include switches, terminals, line of sight, satellite, and cable systems. Gateway interface to the TRI-TAC system occurs through the NC. (Mobile Subscriber Equipment (MSE) Architecture, 1988, p. 1-16)

2. Commercial Office Interface

Commercial office interface allows subscribers to access the local commercial telephone system. The LENS is equipped to accommodate two commercial lines. Each SEN is capable of one.

3. NATO Interface

The MSE system provides for non-secure analog and secure digital communications to miliary systems complying with Standardization Agreements (STANAGs) 5040 (analog interface), 4206 through 4212 and 4214 (digital interface). Analog interface is accomplished using a NATO Analog Interface (NAI) converter (CV-4002/G). One CV-4002/G is authorized to each signal battalion. The NAI device can be installed at a NCS or interfaced using a LOS V2. Figure 13 shows the NAI configured at a NC. Each NCS is capable of NATO digital interface or direct cabling of a NATO switch. (Mobile Subscriber Equipment (MSE) Architecture, 1988, p. 1-17)

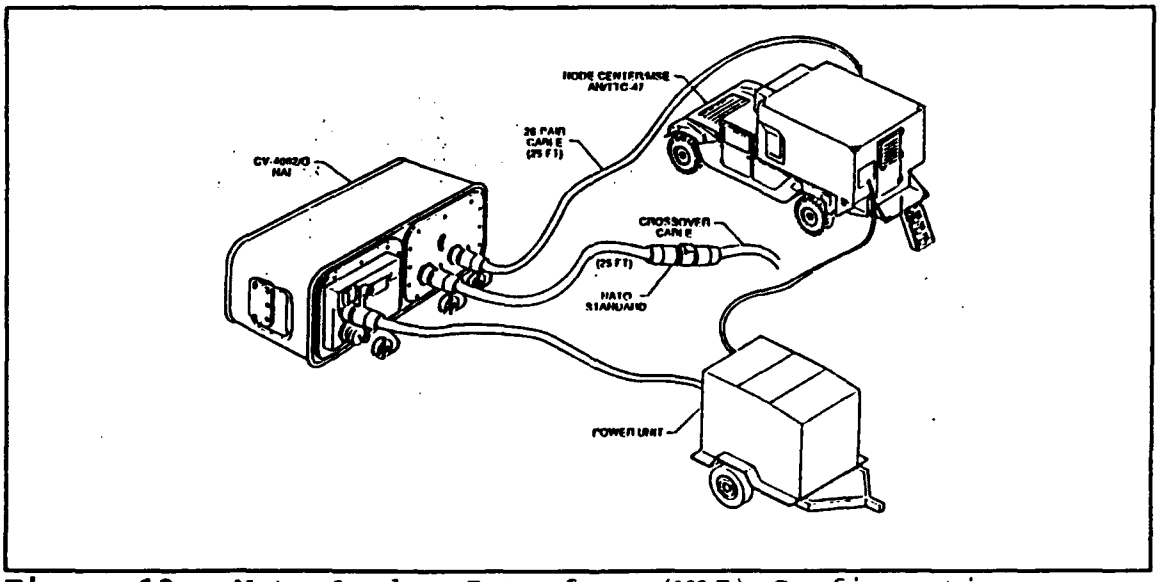

Figure 13. Nato Analog Interface (NAI) Configuration

4. Worldwide Interface

MSE system interface to worldwide access is executed through the EAC communications system. MSE is compatible with and can access both the Automatic Voice Network (AUTOVON) and the Automatic Digital Network (AUTODIN). AUTOVON is accessed through the EAC gateway. AUTODIN is accessed through an EAC AN/TYC-39 record traffic facility. Interface to either network is done through the NCS to AN/TTC-39 circuit switch gateway.

D. SUMMARY

The following is a recapitulation of the major elements of the MSE system.

1. Node Center (NC)

Major switching center of the MSE backbone system. Composed of a switch, four LOS riggs, and a RAU. Is capable of interfacing with five NCs (all LOS), six SENs (four through LOS, two cabled), three RAUs (two through LOS, one cabled),one LEN (LOS), and one SCC (cabled). It has the capability of supporting 26 local wire subscribers. See Figure 9.

2. System Control Center (SCC)

Provides system management functions. Consists of two assemblages (technical and management/planning) at the division and three (technical and two management/planning) at the corps levels. Division SCC is responsible for division sector management. Corps SCC is overall responsible for corps

area. The SCC is cabled to NCS or LENS. Figure 14 depicts a corps level SCC site.

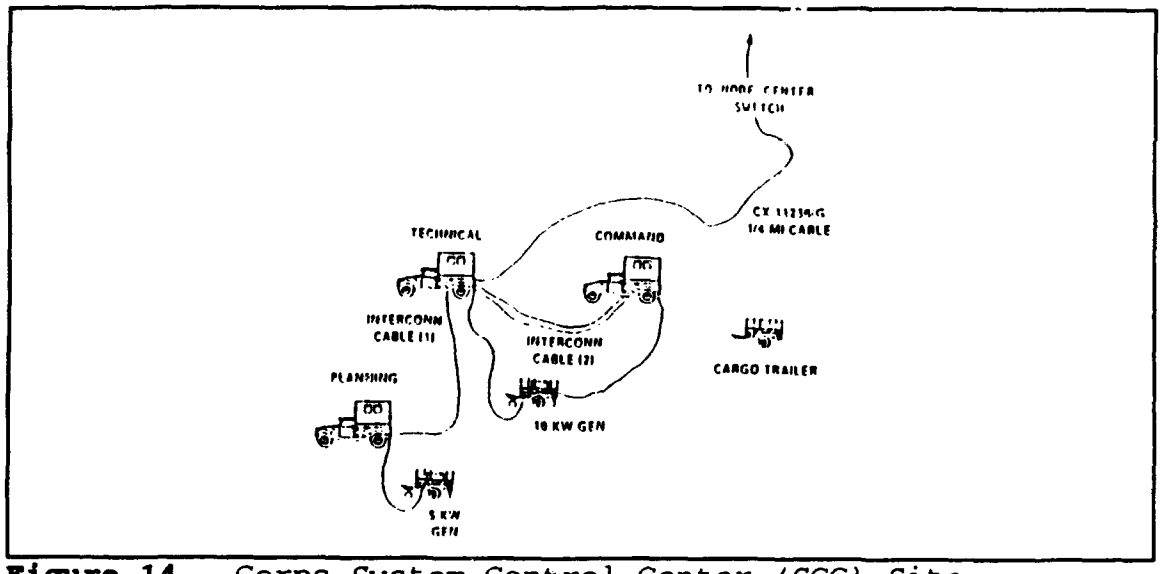

Figure 14. Corps System Control Center (SCC) Site

3. Large Extension Node (LEN)

Provides communications support and access to the MSE network for large command posts (COSCOM, DISCOM, etc.). Consists of a switch, local RAU, and one LOS rig. Linked into NC (either cabled or multichannel multiplexed LOS radio transmission) for network access. Capable of supporting up to 176 local subscribers. See Figure 11.

4. Small Extension Node (SEN)

Provides communications support and access to the MSE network for small CPs (brigade and separate battalion). There are two variations (V1 and V2). Composition of the variants is

the same: a switch and a LOS rig. Ties into NC for network access. Capacities are 26 and 41 subscribers respectively. See Figure 12.

5. Radio Access Unit (RAU), AN/TRC-191

Provides mobile subscriber access to the MSE network. Local assemblages are single shelter and are located at NC and LEN. RRAU is the same as RAU but has a LOS for NC tie-in. Radius of coverage is 15 km. For radio bands see Table IV. RAU's are positioned on the battlefield to provide footprint overlap. See Figure 9 for local RAU connectivity. A RRAU site is depicted in Figure 15.

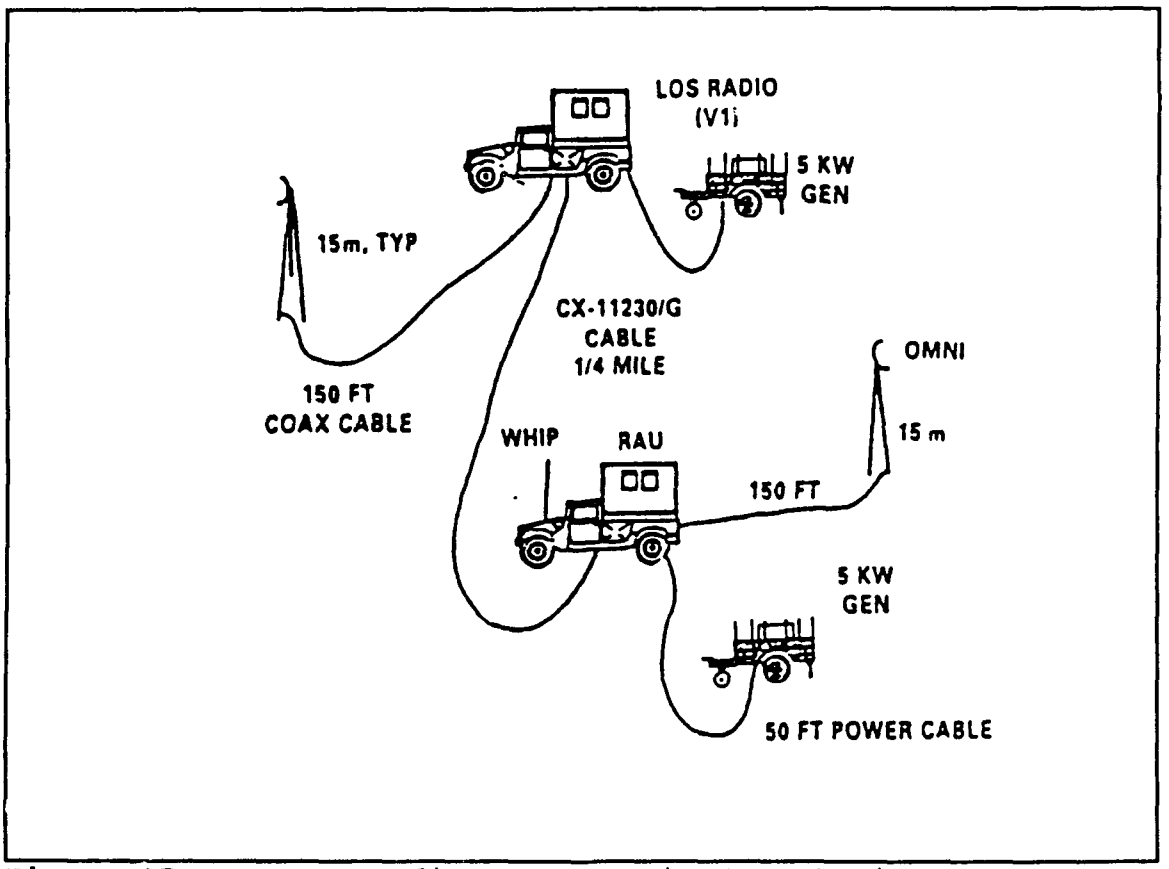

Figure 15. Remote Radio Access Unit (RRAU) Site

6. Line of Sight (LOS) Assemblages

LOS assemblages are used to establish radio links between sites. There are four variations of the LOS rig: V1, V2, V3, V4. LOS connectivity is accomplished using the GRC-226 UHF radio. Planning range for the GRC-226 is 40 km. The GRC-226 have two band variants: band I (225-400 MHz); band III (1,350-1,850 MHz). The V1-V3 are equipped with a spare radio. LOS functionality and number of radios is summarized in Table V.

Table V. LOS VARIANT FUNCTION AND UHF RADIO COUNT

	Function	Number of GRC-226
LOS V1	RRAU and SEN	2
LOS V2	NATO Analog Interface	2
LOS V3	NC	4
LOS V4	LEN	2

7. User Owned and Operated Equipment

There are four devices that are authorized and issued to a user. These devices are: DNVT, FAX, SST and MSRT.

a. Digital Non-secure Voice Terminal (DNVT)

The DNVT is the workhorse for a static subscriber. It is a militarized four wire, push-button telephone. The DNVT is connected to a switch by WD-1 (wire), junction box or Remote Multiplexer Combiner (RMC). As its name indicates it is

not a secure means of communications. The DNVT is depicted in Figure 16.

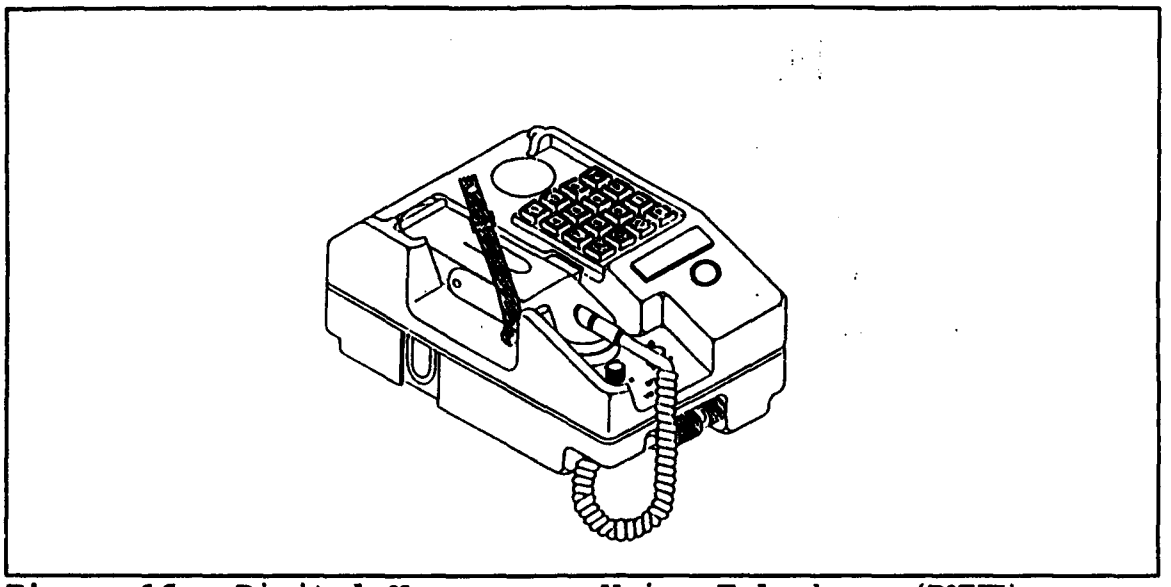

Figure 16. Digital Non-secure Voice Telephone (DNVT)

b. Facsimile Terminal (FAX)

The lightweight digital facsimile terminal (FAX) is a militarized four wire FAX machine. It is employed in conjunction with the MSRT (using DSVT port) or DNVT. See Figure 17.

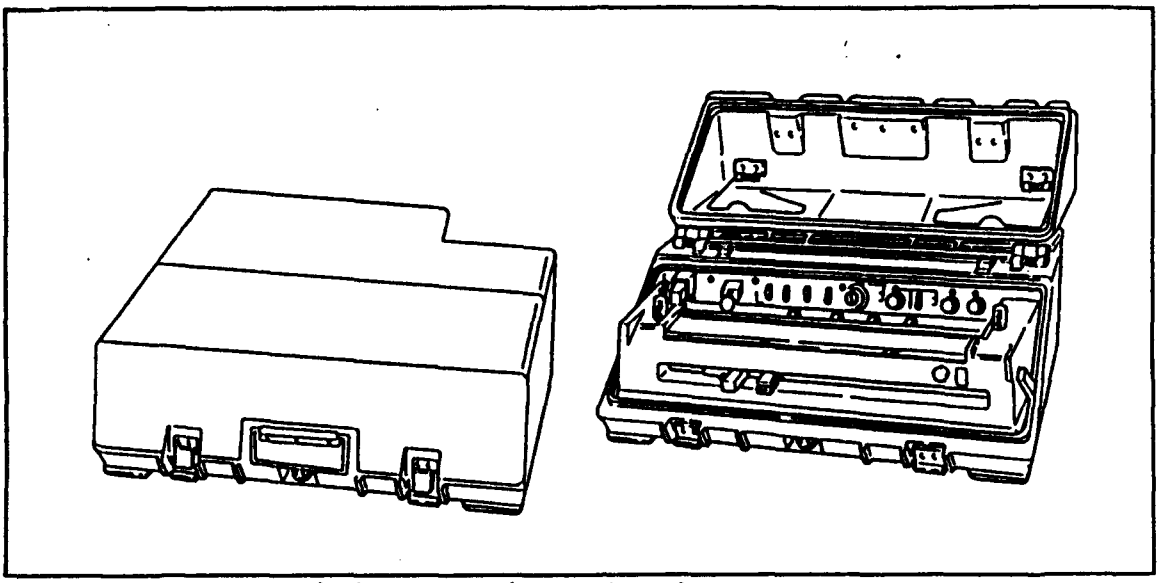

Figure 17. Facsimile Terminal (FAX)

c. Single Subscriber Terminal (SST)

The SST is a microprocessor which functions as a data/message handling, transmission and processing device. It operates over the data port of the DNVT and DSVT. Data passed by the SST over MSE enables interoperability with the AN/TYC-39 automatic message switch at EAC.

d. Mobile Subscriber Radio Telephone Terminal

The MSRT supports mobile subscribers with secure voice and data transmissions. It consists of a Digital Subscriber Voice Terminal (DSVT), radio, and installation kit. It is either vehicular mounted or stand alone. Access to the MSE network is provided via the RAU. Typical MSRT HMMWV installation is depicted in Figure 18.

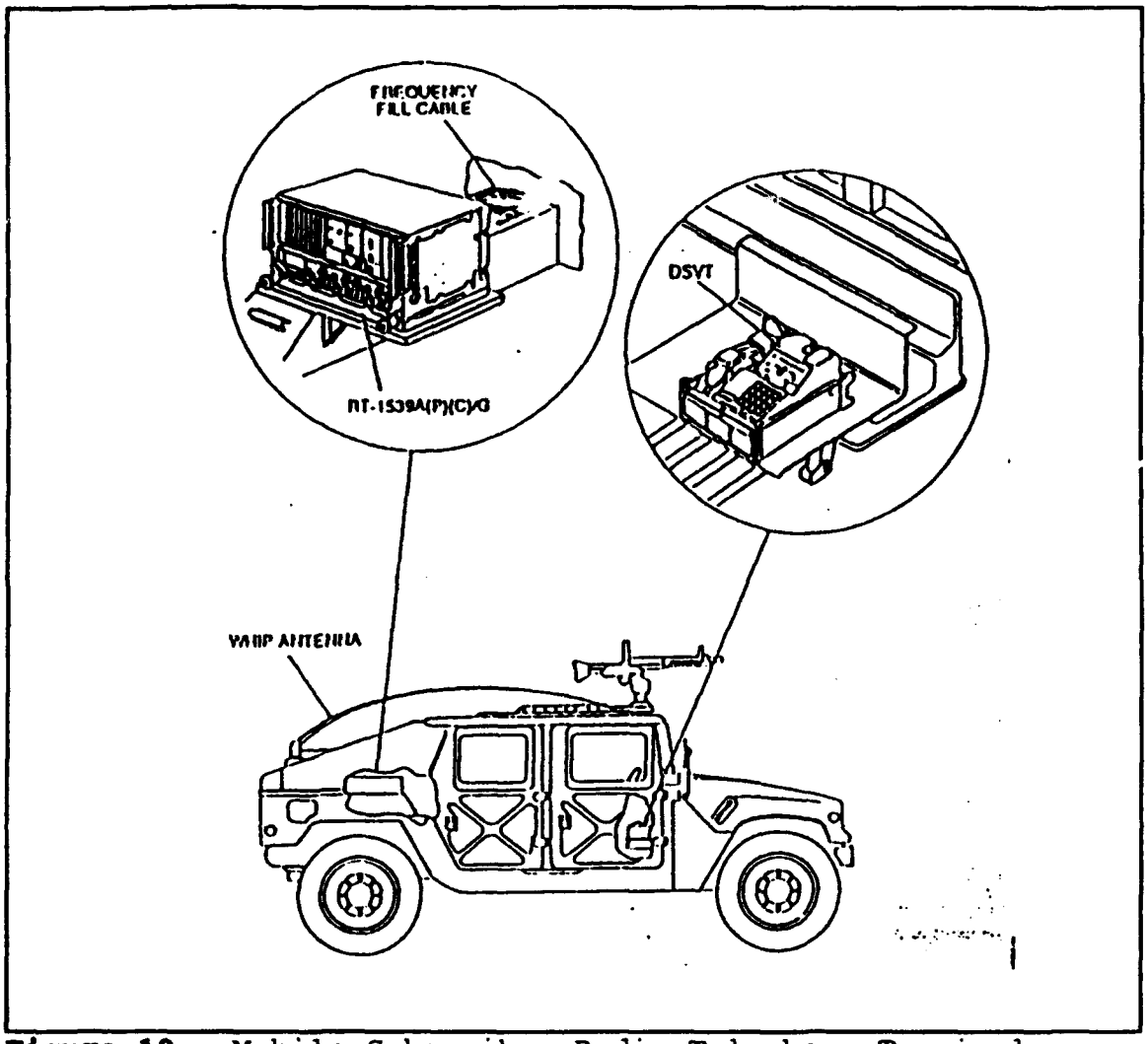

Figure 18. Mobile Subscriber Radio Telephone Terminal

8. Radio to Wire Integration (RWI)

Radio to Wire Integration is accomplished with the use of the KY-90. Each signal battalion has four KY-90s. The KY-90 is connected to an FM radio and wired in to a switch. Operator interface is required to initiate an RWI call. Figure 19 depicts the KY-90.

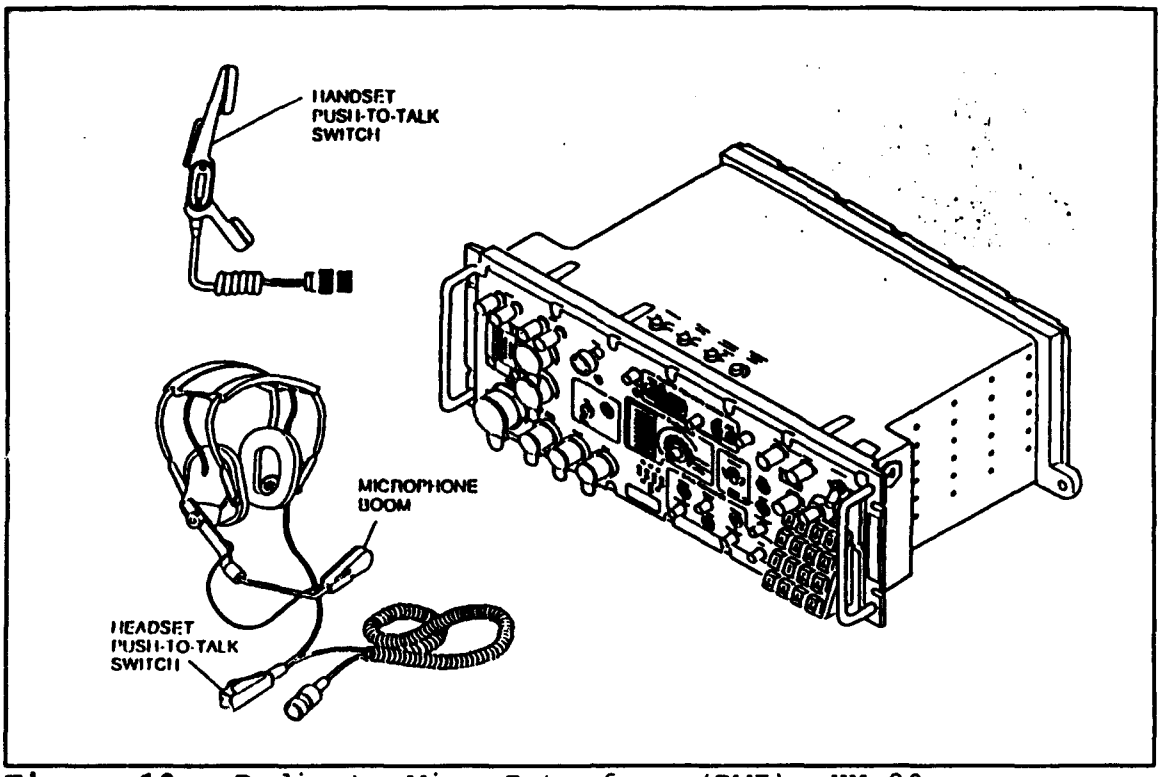

Figure 19. Radio to Wire Interface (RWI), KY-90

9. Connectivity

Multiple links between each NC is paramount to ensure path survivability. A NC is inter-connected to a minimum of two other NCs. The SCC operations team will strive to position NCs to ensure multiple NC to NC connectivity. The LEN links to two different nodes. If one node fails the LEN can continue to access the network. The SENs supporting brigades are linked to different NCs to reduce the effects of NC outages. Figure 20 is an example of a reduced MSE network established at division level.

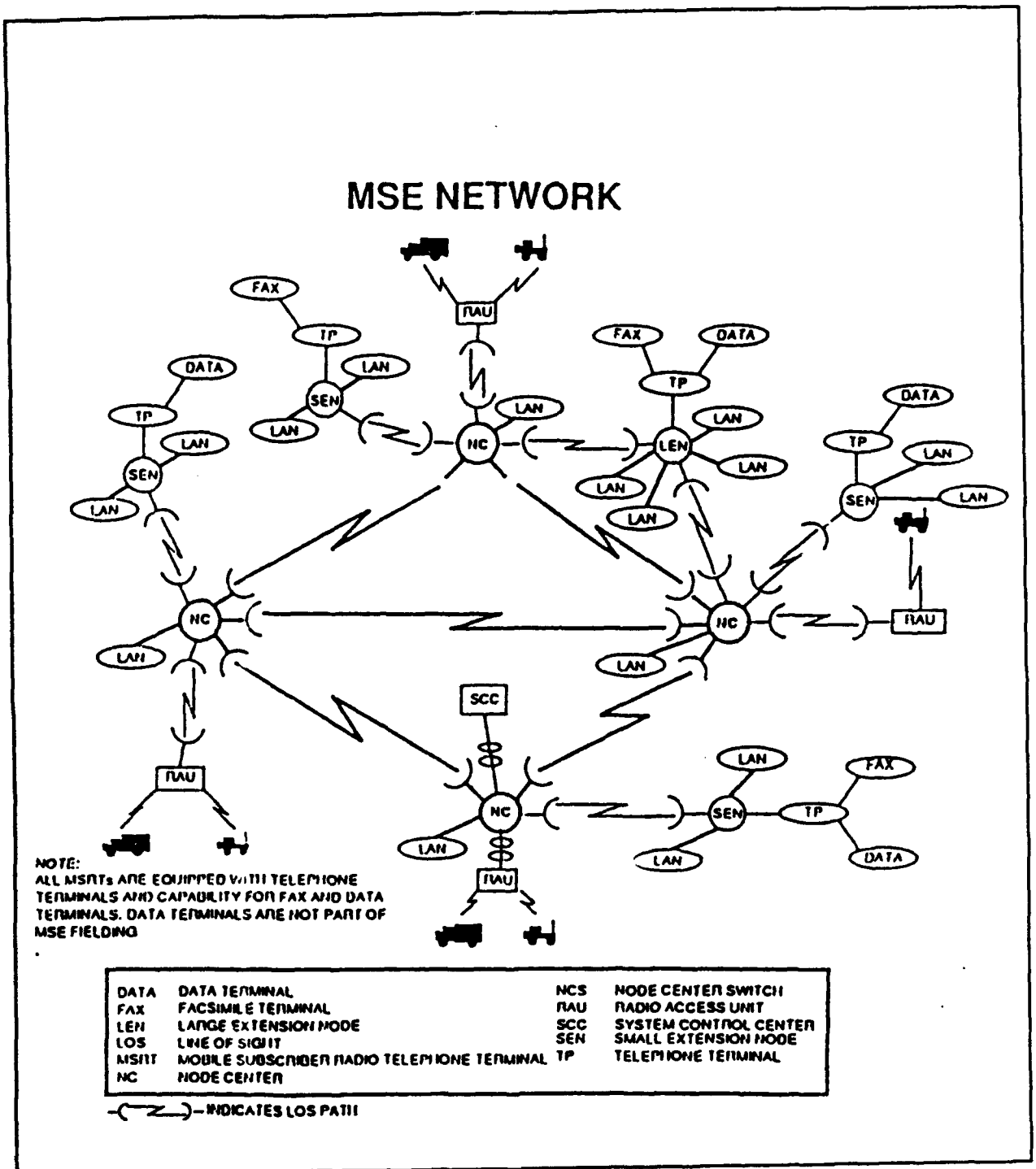

Figure 20. Division Level MSE Network

IV. UNIFIED COMMAND AND JOINT TASK FORCE COMMUNICATIONS

A. UNIFIED COMMAND C2 STRUCTURE

Unified commanders are faced with supporting national objectives in the face of historic world changes. To support national objectives a unified commander must develop theater strategies that address this rapidly changing world. Strategies must exploit technological advancements (C3I and weapons systems) and provide the flexibility to respond to contingency operations ranging from humanitarian aid to high intensity conflicts (e.g., Desert Shield/Storm). Constraints imposed on a Commander-in-Chief (CINC) are down-sized forces, reduced forward-basing and fiscal resources. The operational shift from theater conflict to regional contingency operations, and its inherent requirement for rapidity, has necessitated an emphasis on Joint Task Force (JTF) operations. The unified CINC's C2 structure must be flexible to support a myriad of JTF operations over a range of diverse situations. The required agility of a C2 system in support of JTF operations has driven a paradigm shift in the unified commands' traditional three-echelon C2 structure to a two-echelon C2 structure. (U.S. Pacific Command Contingency Operations C3I Support Plan, June 1992, pp. 1-2)

1. Three-Echelons of Command and Control

Traditionally a unified command C2 structure is three tier. This structure is based on directing operations in theater wide or global conflicts. In this concept a CINC provides theater direction to the designated component (or subunified commander) who provides planning, support and forces to the warfighter. Intelligence support to the CINC is provided by the Joint Intelligence Center (JIC). Execution of tactical operations, under the direction of the warfighting commander, is done by the Joint Special Operations Task Force (JSOTF), Army Forces (ARFOR), Air Force Forces (AFFOR), Navy Forces (NAVFOR) and Marine Forces (MARFOR). These forces, as well as logistics support, are provided to the warfighter by the component Service commanders. Although this structure passes the "gut check" for the standard military hierarchal command concept it does not muster the common sense test for expedient C2. To streamline the C2 structure, U.S. Commander-in-Chief, Pacific (USCINCPAC) requested the Defense Information Systems Agency (DISA) and the Intelligence Communications Architecture (INCA) Project Office to undertake the project of developing a concept of operation for the transition from a three-echelon to a two-echelon C2 structure. Figure 21 depicts the three-echelons of command and control for Pacific Command. (U.S. Pacific Command Contingency Operations C3I Support Plan, June 1992, p. 2)

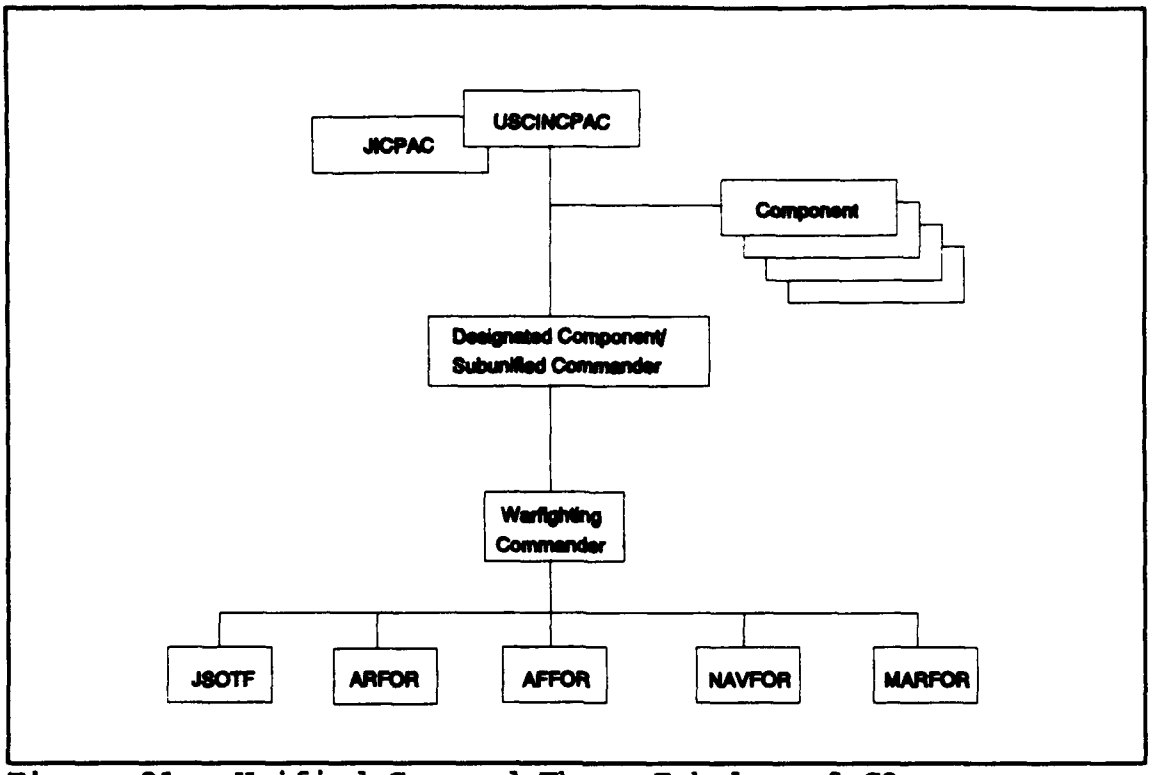

Figure 21. Unified Command Three-Echelon of C2

2. Two-Echelons of Command and Control

The two-echelon C2 structure emphasizes the direct connectivity from the CINC to the Commander Joint Task Force (CJTF). Under this concept the USCINC will monitor the situation, designate the CJTF, exercise direct operational control over the JTF and provide theater direction. As in the three-echelon C2 structure, Service commanders will provide forces and necessary logistic support to the CJTF, as directed by the CINC. The CJTF will coordinate combat forces and provide direction to the component commanders on the

prosecution of tactical operations. The Pacific Command two-echelon C2 structure is depicted in Figure 22. (U.S. Pacific Command Contingency Operations C3I Support Plan, June 1992, pp. 2-3)

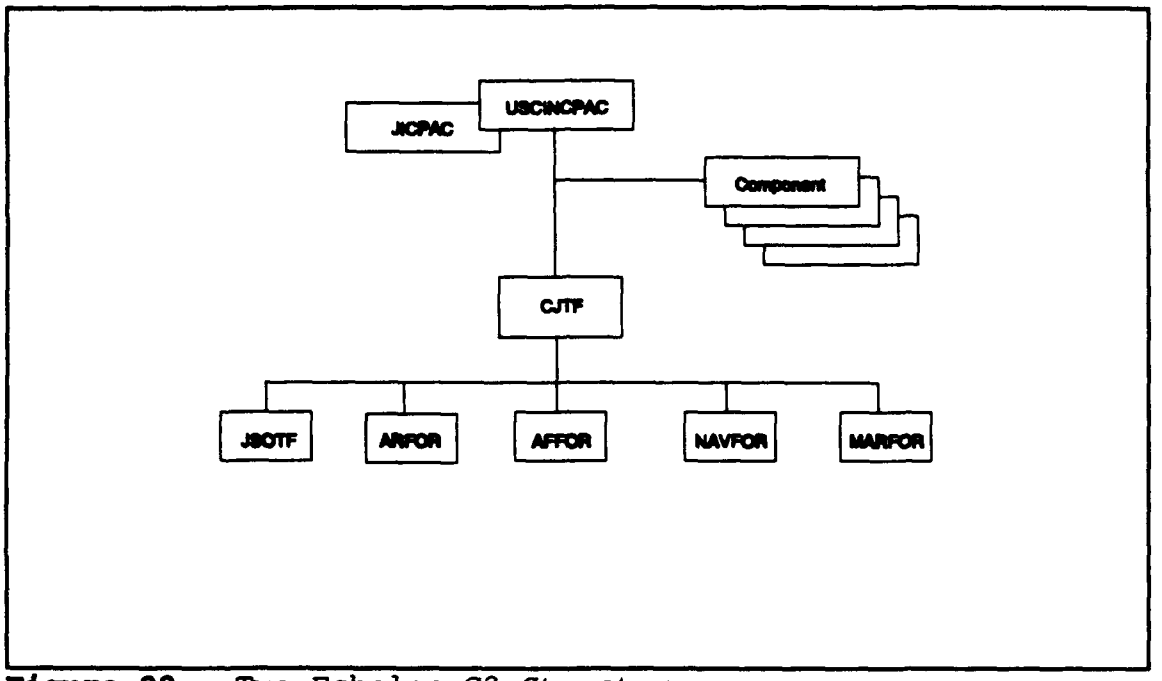

Figure 22. Two-Echelon C2 Structure

B. JOINT TASK FORCE COMMUNICATIONS

Although the previous section presented the baseline C2 structure for the unified command, the command relationship transition during JTF operations is tenuous (e.g., from amphibious assault to activation of the commander of land forces (COMLANFOR)). A more complete representation of typical command relationships during peacetime and the activation of

a JTF are presented in Figure 23. (JCS Communications Manual, 1988, p. 1-2)

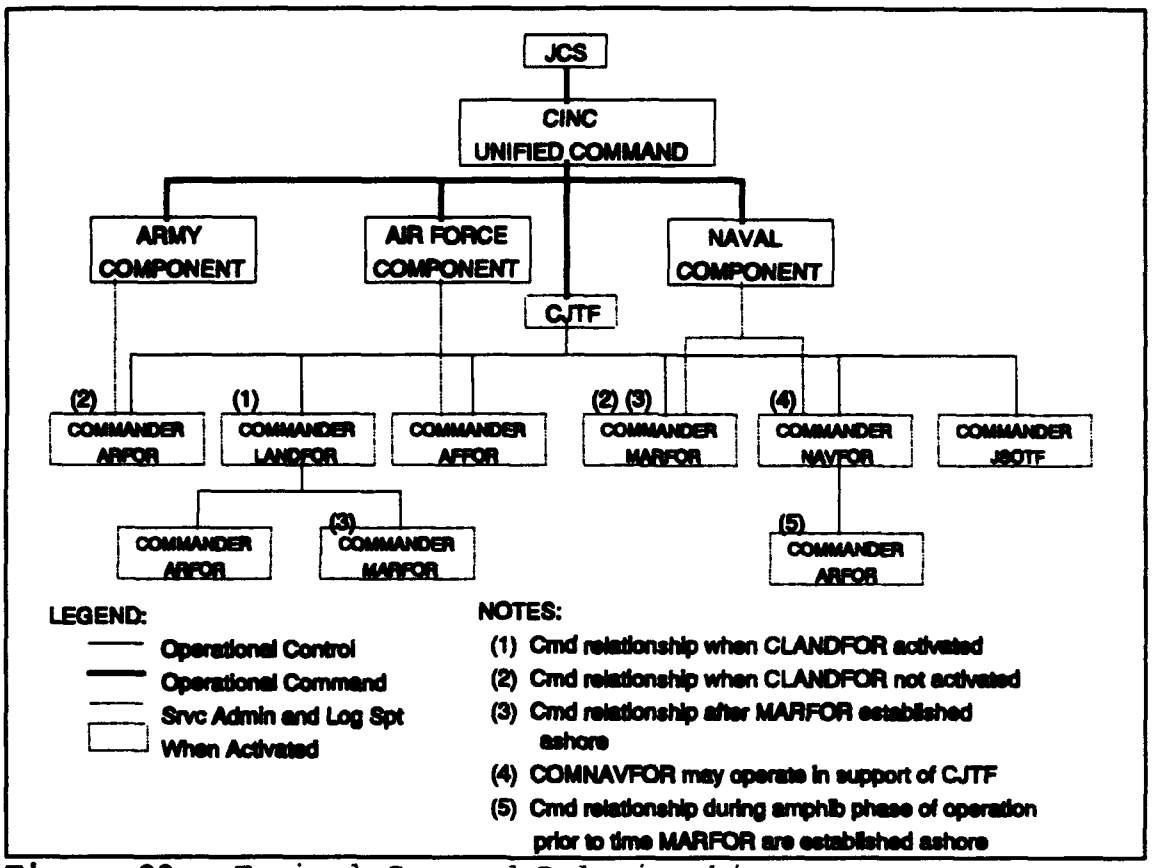

Figure 23. Typical Command Relationships

1. Joint Task Force Communications Links

Command relationships dictate communications paths. Accordingly, the CJTF must be able to communicate with the supported CINC and all assigned forces (i.e., Air Force, Army, Navy, Marine, and special operations). Communications are provided between units/commands as follows:

- senior to subordinate (i.e., higher to lower)
- supporting to supported
- reinforcing to reinforced
- left to right
- between adjacent units as directed by common senior
- by unit gaining attachment

The JTF communications plan must encompass predeployment, advance forces deployment, deployment, employment, and redeployment. In addition to the command relationship driven communications links the JTF must incorporate the extension of the Defense Communications System (DCS) into the joint operational area (JOA). Connectivity from the hub (JTF HQ) to external activities (CINC, DCS, forces) is accomplished utilizing various systems. The three typical systems are the Ground Mobile Forces (GMF) Super High Frequency (SHF) satellite system, High Frequency (HF) Intermediate Staging Base (ISB) radio system, or terrestrial multichannel systems. Survivability of this C3 system is paramount. Based on assets available, dispersed terminals providing multiple links between major headquarters is preferred. (JCS Communications Manual, 1988, p. 1-3, p. K-3-1)

2. Communications Support to the JTF HQ

The CJTF may request communications support from the Joint Communications Support Element (JCSE). Authority for deployment of the JCSE rests with the Joint Chiefs of Staff

(JCS). If approved for use, the JCSE will typically support both the JTF HQ and the Joint Special Operations Task Force (JSOTF) HQ. The JCSE responsibilities include the Installation, Operation and Maintenance (IOM) of Communications and Electronics (CE) facilities to support these HQs. If required, the JCSE is capable of the IOM of satellite terminals at service component and CINC headquarters. The JCSE will also provide connectivity between the JSOTF HQ and its subordinates. (JCS Communications Manual, 1988, p. 1-3)

If the JCSE is not available for support it is incumbent upon the CJTF to identify CE support requirements to the supported CINC. The CINC will task service components for communications assets. (JCS Communications Manual, 1988, p. 1-3)

3. Subordinate Force Communications and Electronics

Installation of the Joint Communications Network (JCN) is accomplished by the individual services' execution of their joint CE responsibilities. The core of the JCN is the switching center. Accordingly, the following is a description of JTF subordinate force HQ major C2 links, switching equipment and responsibilities.

a. Commander Army Forces (COMARFOR)

The COMARFOR major subordinate units are maneuver divisions and support commands (e.g., COSCOM). All Army

switches are Tri-Service Tactical Communications System (TRI-TAC) compatible (most are hybrids). The Army gateway switching assemblages are the AN/TTC-39 (voice traffic) and the AN/TYC-39 (record traffic). The tactical switches are the AN/TTC-46/47/48 (MSE, see Chapter III). COMARFOR responsibilities include, but are not limited to those identified below. (JCS Communications Manual, 1988, pp. 1-5, 1-6)

- IOM of CE facilities required to accomplish basic tasks and responsibilities as assigned.
- Provision of personnel and equipment for air traffic control in coordination with Commander Air Force Forces (COMAFFOR).
- Provision of personnel and equipment for air defense operations in coordination with Area Air Defense Commander (AADC).
- Provision of communications assets to support air field security operations in coordination with COMAFFOR.
- Provision of personnel and equipment for "link-up" communications with Marine forces and special operation forces.
- Provision of terrestrial multichannel communications from the COMARFOR to the JTF HQ and terminate all joint communications at COMARFOR and Special Forces Operating Base (SFOB) HQs.
- Provision of base support to JCSE (when deployed) and other components having communications terminals at ARFOR and SFOB HQs.

b. Commander Air Force Forces (COMAFFOR)

The major subordinate activities to the COMAFFOR are the Tactical Air Control Center (TACC), Wing Operation Center (WOC) and Control and Reporting Center (CRC). The Air

Force switch assembles are the TRI-TAC AN/TTC-39 (voice) and AN/TYC-39 (record). These switches are used to support C2 at all levels (base and gateway communications). COMAFFOR responsibilities include, but are not limited to those identified below. (JCS Communications Manual, 1988, p. 1-6)

- IOM of CE facilities required to accomplish basic tasks and responsibilities as assigned.
- Provision (or arrangement) for aircraft movement CRC facilities en route, at staging bases and in designated areas of operation. Coordination of air operations as required (i.e., COMARFOR, COMNAVFOR, COMMARFOR, etc.).
- Coordinate for aircraft control and radio frequencies.
- State and distribute navigational aids information.
- Planning and provision for communications to support Joint Tactical Air Operations (JTAO).
- Coordinate for and establish procedures for air traffic control and regulation within combat area. Provide personnel and equipment in support of this tasking.
- Provision of effective radar surveillance necessary for identification and air defense operations.
- Assign and distribute Identification Friend or Foe (IFF) operating instructions and procedures.
- Provision of terrestrial multichannel communications from the COMAFFOR to the JTF HQ and terminate all joint communications at COMAFFOR and Air Force Special Operations Base (AFSOB) HQs.
- Provision of base support to JCSE (when deployed) and other components having communications terminals at AFFOR and AFSOB HQs.

c. Commander Naval Forces (COMNAVFOR)

The COMNAVFOR has no specific major subordinate command HQ. The Navy does not possess any large switchboards. Commanders of naval task forces/groups/units requiring ship-shore-ship termination for record traffic and point-to-point teletype connectivity request and establish terminations in accordance with normal Fleet Tele-communications Operating Procedures (FTOP). The COMNAVFOR CE responsibilities include, but are not limited to those identified below. (JCS Communications Manual, 1988, p. 1-3, pp. 1-6, 1-7)

- Provide and operate CE facilities required to accomplish basic tasks and responsibilities as assigned.
- Provide and operate CE facilities in support of air operations as required.
- Identify and distribute ship-borne navigational aids, frequency channel and station identifiers.
- Provide terminal communications equipment at the NAVFOR HQ (afloat or ashore).
- Provide base support to JCSE (when deployed) and other components having communications terminals at NAVFOR and Navy Special Warfare Task Group (NSWTG). Terminate all joint communications at these HQ (i.e., COMNAVFOR and NSWTG).
- Ensure UHF SATCOM terminal, HF radio, teletype and voice terminal equipment are available aboard ship to meet ship-to-shore requirements.
- Provide support to Marine Corps amphibious force while embarked.

d. Commander Marine Forces (COMMARFOR)

The major subordinate elements to the COMMARFOR are maneuver divisions and air wings. The Marine Corps, like the Army and Air Force, possess TRI-TAC switches. COMMARFOR responsibilities include, but are not limited to those identified below. (JCS Communications Manual, 1988, p. 1-1, p. 1-7)

- IOM of CE facilities required to accomplish basic tasks and responsibilities as assigned.
- When afloat communications to the COMMARFOR will be provided by COMNAVFOR. When ashore the COMMARFOR will provide personnel and equipment for establishment of terrestrial multichannel communications from COMMARFOR HQ to the JTF HQ, "link-up" communications with COMARFOR, and terminate all joint communications at COMMARFOR.
- Provide base support to JCSE (when deployed) and other components located at COMMARFOR.
- If Marine Corps air operations are required, the COMMARFOR will provide, within the MARFOR Area of Responsibility (AOR): aircraft control and navigational assistance; coordination of aircraft control and reporting radio frequencies; promulgation of navigational aid information; Close Air Support (CAS) communications; and effective radar surveillance for IFF and air defense operations.

e. Joint Special Operations Task Force (JSOTF)

The major subordinate units of the JSOTF are the Special Forces Operations Base (SFOB, Army proponent), Air Force Special Operations Base (AFSOB), and the Navy Special

Warfare Task Group (NSWTG).[23] There are no communications responsibilities for this organization. Communications are provided to the JSOTF by the JCSE or the component services (as described in the sections above). (JCS Communications Manual, 1988, pp. 1-3, 1-7)

4. Defense Communications System (DCS)

The Defense Communications System (DCS) is extended into the JOA through one of three means. These are: the termination of SHF satellite links at designated Defense Satellite Communications System (DSCS) entry stations; HF radio links into designated HF DCS entry stations; and UHF single-channel satellite links into designated UHF ground entry points. Terminals (i.e., Tactical Satellite (TACSAT), LOS, and tropospheric scatter) required for DCS and tactical use are provided by the individual service component or, if available and requested, JCS. (JCS Communications Manual, 1988, pp. 1-3)

The Army habitually uses the AN/TSC-85B SHF Satellite Communications Terminal in conjunction with a DSCS gateway terminal for DSCS interface. The AN/TSC-85B can communicate with the AN/TSC-93B, AN/TSC-94, and AN/TSC-100A. Although the total channel/group capacity is dependant upon program configuration, it can accept up to 96 individual channels and

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[23] For a discussion on Marine Expeditionary Units (MEU) Special Operations Capable (SOC) see Cushman, June 1991, p.44.

can range from 16 to 4664 kbps. (Secure Tactical Data Network-3 (STDN-3) Demonstration Report, April 1993, p. G-1)

5. Summary

In general, and as a minimum, the JTF typically must communicate with six major headquarters (supported CINC and subordinate forces) and establish links to the DCS. Communications are established using GMF SHF satellite, HF ISB radio, or terrestrial multichannel systems. The inter-service (not intra-service) circuit links are referred to as the Joint Communications Network (JCN). In essence the JCN extends the DCS into the tactical arena. Responsibility for maintaining the (JCN) rests with the J-6 (Director of Information Systems or CE staff equivalent). Management is accomplished by the JTF J6 Joint Communications Control Center (JCCC) via Service System Control Centers (SYSCON in general, SCC in the case of the Army). The JCN provides the service of both voice and record transmissions. An example of a JTF communications system diagram is presented in Figure 24. (JCS Communications Manual, 1988, p. 2-1, p. K-3-1)

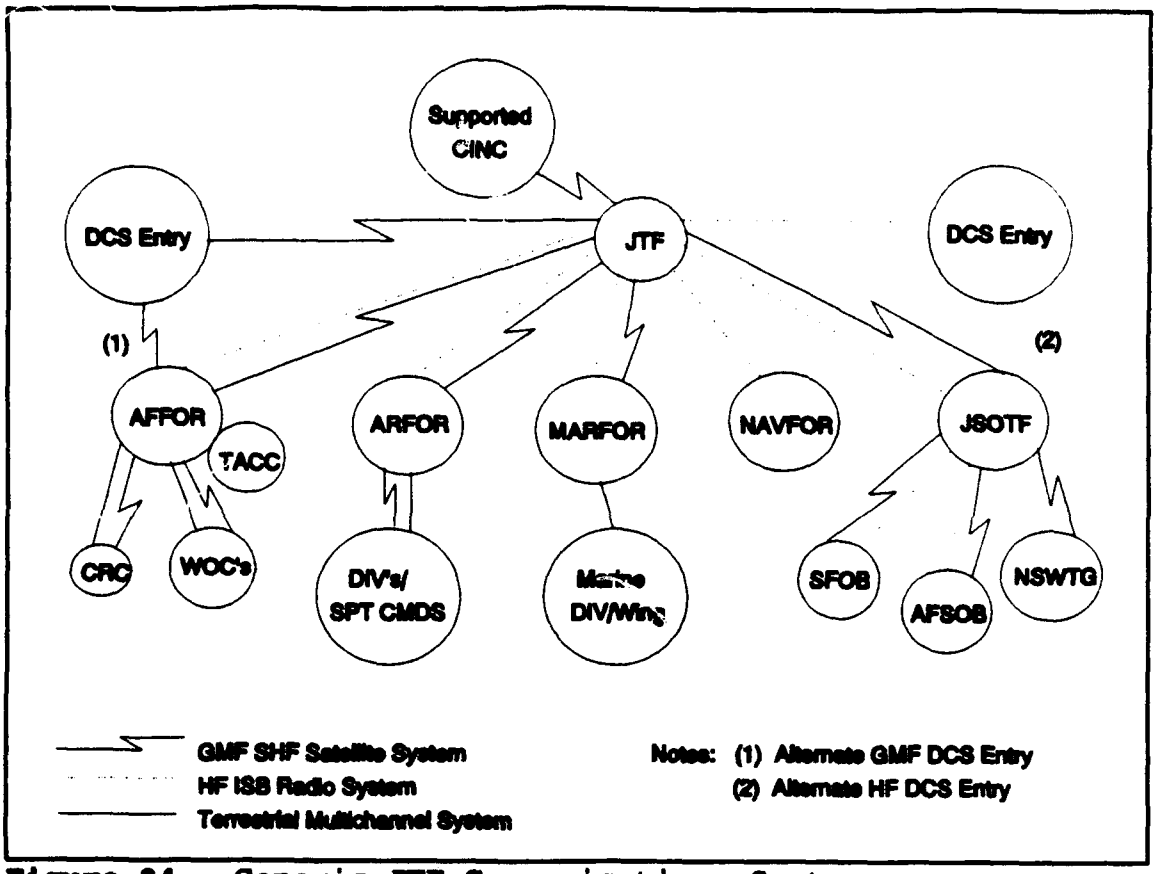

Figure 24. Generic JTF Communications System

C. SERVICE COMMUNICATIONS INTEROPERABILITY

Communications interoperability is driven by two primary factors: doctrine and equipment specifications.

1. Joint Doctrine

One of the driving forces behind communications interoperability is the concept of joint doctrine. The composition of the JTF and how the CJTF employs his forces will dictate required communications. Doctrine is defined in Joint

Publications 1-02 (under revision as of February 1994) as "Fundamental principles that guide the employment of forces of two or more Services of the same nation in coordinated action toward a common objective."[24] Though austere, this definition provides the baseline for joint operations to be built upon. Joint Publication 6-0 (C4 Systems, p. I-1) states that the fundamental objective of a C4 system is:

> ...to get the critical and relevant information to the right place in time to allow forces to seize the opportunity and meet the objectives of the operational continuum.

The publication goes on to state that the basic C4 doctrine is to provide an unbroken chain of communications from the National Command Authority (NCA) through the intermediate levels to the Service components' subordinate commanders. Both are lofty and unequivocal. However, the C4 doctrine fails to provide succinct directives to participants. This may be because of the volatile nature of JTF operations and the quandary of JTF composition.[25] The current lack of doctrine detail is understandable but unacceptable. This situation is being rectified by the Joint Staff's J7 (Operational Plans and Interoperability).

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[24] Of the 100 Joint Publications under the Joint Publications System, 39 are approved, 10 are under revision, and 51 are under development. (Sovereign, Class notes, 7 Apr 1994)

[25] From 1973 to 1993 there were 104 notable international crises affecting the U.S.. These crises ranged from humanitarian aid (e.g. Hurricane Hugo) to large armed conflict (Desert Storm). (Woodward)

Likewise Service specific doctrine guides intra-service communications systems architectures. Each Service habitually establishes their own communications network. To control the network each Service has network management cells. It is the responsibility of the JTF J6 to mesh these disjointed Service networks into a compatible package. Gateways must be established between intra-service networks and the DCS. Doctrines of the separate Services not withstanding, the workhorses of the JCN are the switches.

2. Switching Equipment

The backbone of the JCN are the switches. Switches provide the routing and connectivity (i.e., gateways) between networks. As Service doctrines have evolved so have their communications systems to support them. This has led to a divergence between Service systems. To bring the Services on-line for interoperability the TRI-TAC program was instituted in May 1971 (see Chapter III). The driving tenet of TRI-TAC was that equipment be built to provide technical inter-operability.

The heart of the JCN is the TRI-TAC AN/TTC-39 switchboard. The Army, Air Force and Marines all possess the AN/TTC-39. However, twenty-three years after the establishment of the TRI-TAC program, there are significant technological differences between service AN/TTC-39s. Most notable is the routing capability of the switches.

All Army MSE tactical switchboards use a flood search routing scheme. Flood search routing is an automated process for selecting the optimum path for a call to be connected. Army AN/TTC-39s (found at the corps level) have been converted from deterministic routing to the flood search routing scheme.

The Air Force has maintained their AN/TTC-39s in a deterministic routing mode. Deterministic routing requires intensive and detailed system engineering. The route of each call through the network is predetermined and programmed into the switch.

The Marine Corps has another version of the AN/TTC-39 with similar technical differences as the above. With the Marine Corps' recent rejection of the MSE operational test and evaluation, upgrades to the AN/TTC-39 remain to be seen. (Egge)

Can the services' switchboards "talk" to each other through gateways? Unequivocally yes. However, the difference in routing schemes has created a seam. In effect, the different numbering schemes and dialing procedures have created a less than user friendly system. Where the Army has instituted fixed subscriber numbers (regardless of geographical location) the Air Force has fixed phone numbers by location. The confusion that this creates in cross network communications can not be understated.

3. Interoperability Performance

Until recently the issue of inter-service communications interoperability has received scant support. Workarounds for joint operations have been in existence for as long as the formation of the first continental army.[26] Joint operations were coordinated with service liaison personnel. This approach continues today with the emplacement of service specific communication equipment at distant ends. However, the renewed emphasis on joint operations is coddling a migration toward more compatible communications equipment and C2 systems.

a. Current Status

The best measure of current joint inter-operability capabilities is seen in the communication performance during Desert Shield/Desert Storm. The circuit-switched common-user network was formed by the interconnection of DCS, TRI-TAC, MSE, and Combat Net Radio (CNR). This network successfully provided for global connectivity from the tactical arena to anywhere in the world. A thumbnail sketch of the circuit-switched network is presented in Figure 25. (Campen, October 1992, pp. 11-15)

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[26] A discussion on the evolution of joint operations can be found in *Command and Control of Theater Forces: The Future of Force Projection Operations* by John Cushman (June 1991, pp. 27-48).

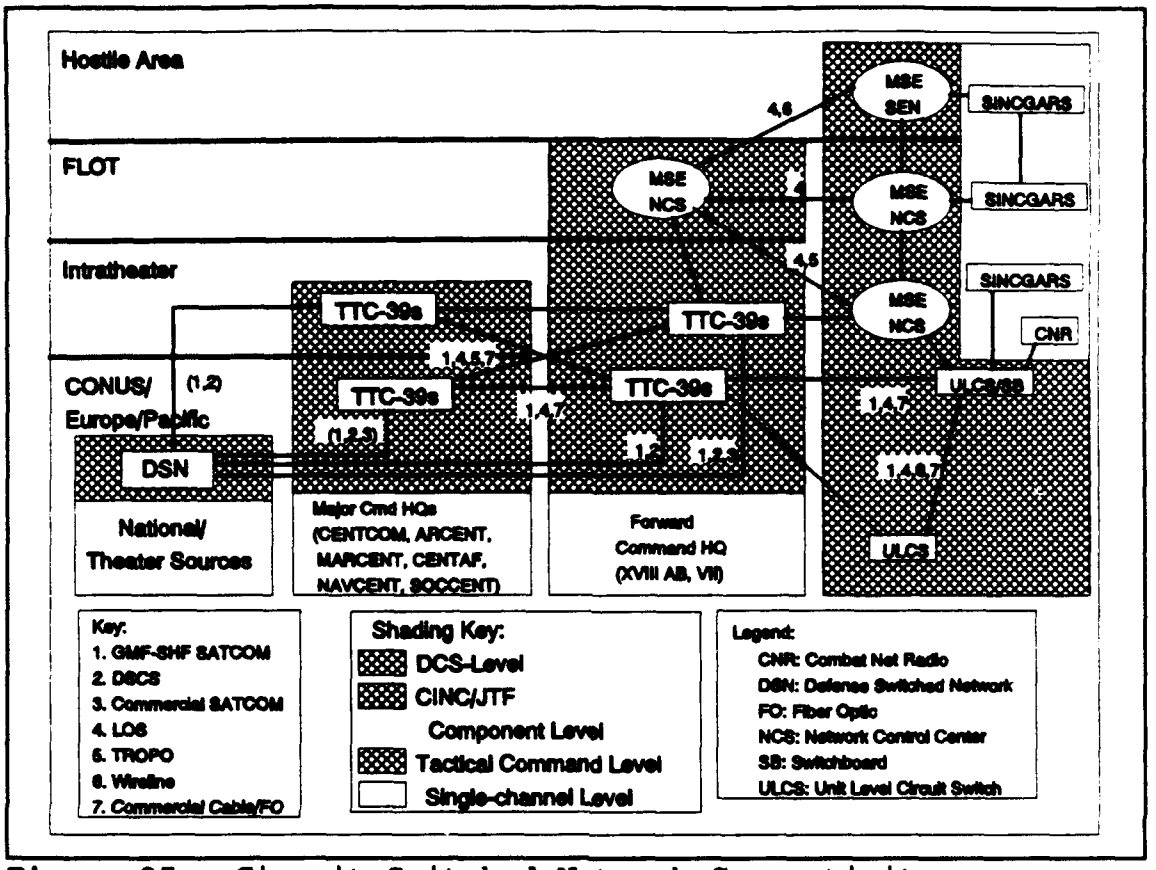

Figure 25. Circuit Switched Network Connectivity

The circuit switched network depicted above was established to support common users. The network was capable of transmitting both secure and non-secure voice, data, and facsimile. This network was noted for its example of end-to-end connectivity using a variety of interconnected strategic and tactical communications systems. A couple of positive

lessons learned are identified below.[27] (Wentz, Perspectives on C3I Performance in Desert Shield/Desert Storm: Communications, October 1991, p. 12, p. 14)

- Connectivity. Typically a few gateway switches at the DSN (located in CONUS, Europe and Pacific) are connected to a few major command gateways (AN/TTC-39s) in the AOR. This limits the volume of customer access and grade of service. During Desert Shield/Desert Storm, over 20 AN/TTC-39s in the AOR were directly homed to eight DSN switches. This improved the traffic grade of service and conserved on transmission resources (transmission from a central hub TTC-39 to outlying TTC-39s was eliminated). A valuable addition to connectivity was the use of commercial satellites links.
- Mobile Subscriber Equipment (MSE). This was MSE's trial by fire. Its technical capabilities were proven to perform well.

b. Concerns

Successful joint communications interoperability was achieved during Desert Shield/Desert Storm. The experience also revealed some shortcomings. The following is brief description of some. (Wentz, Perspectives on C3I Performance in Desert Shield/Desert Storm: Communications, October 1991, p. 12, p. 14)

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[27] One can easily become inundated with lessons learned from the Persian Gulf War. Three noteworthy documents for more information on communications and C3 lessons are Annex H to MITRE's *Perspectives on C3I Performance in Desert Shield/Desert Storm* (see reference list under Wentz), *Conduct of the Persian Gulf War*, Final Report to Congress, Chapters I through VIII and *The First Information War* by Alan Campen.

- Connectivity. Although the traffic grade of service was improved with the increase in direct TTC-39 to DSN homing, traffic engineering of routing over the DSN/tactical interface was greatly increased (i.e., the complexity of installation and trouble shooting of out of AOR circuits).

- Mobile Subscriber Equipment (MSE). Dispersion of forces and the pace of battle pushed distances between node centers and extension switches beyond equipment (i.e., LOS) capabilities.

- Quality of Service. Regardless of the volume of communications assets employed in the AOR the network Grade of Service (GOS) varied from poor (40% GOS) to good (>85% GOS). This variation is based on traffic surges, balancing and routing.

- Packet Data. The current tactical links are not designed for packet data services. As services C2 migrates to a digitally driven common battle picture this short fall will increase in criticality.

In general it can be said that joint networks work. However, joint emphasis is required to improve future joint networks. As a minimum, gains must be made in traffic engineering (e.g., route programming, fault isolation and restoral) and upgrading trunk capacity. (Wentz, October 1991, p. 14)

D. RECAPITULATION

JTF missions are diverse and require a flexible and responsive C2 structure. USPACCOM's study of the transition of the Unified Command from a three echelon to two echelon command structure appears to be a step in the right direction.

However, restructuring alone is not an end to the means. Petronius Arbiter, in 210 B.C. stated

> We trained hard...but it seemed that every time we were beginning to form up into a teams we would be reorganized ...I was to learn later in life that we tend to meet any new situation by reorganizing: and a wonderful method it can be for creating the illusion of progress while producing confusion, inefficiency and demoralization.

Restructuring should streamline the C2 but its underpinnings must be doctrine. How we fight as a joint force must be delineated. Responsibilities must be fixed. Joint doctrine is still experiencing growing pains. As it matures nebulous concepts will solidify and provide for more effective Service interfacing. The completion of the Joint Publications will see this to fruition.[28]

In the interim, the U.S. must continue to be prepared to respond to global crisis or threat to national security. Services must continue to strive for complete communications interoperability. TRI-TAC equipment provides a good baseline for interoperability but its mutation among the services has made connectivity engineering intensive.

Desert Shield/Desert Storm is a shining example of innovative engineering. At the time Desert Storm began the network included satellite and terrestrial communications

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[28] Some confusion exists in the organization of Joint Publications. Specifically in delineation of doctrinal areas of responsibility. Example: CE operations is dictated by JPUB 6-0 (C4 Systems) however, three C2 publications (JPUB 3-13 (C2W), JPUB 3-56 (C2 Doctrine), and JPUB 3-56.1(C2 for Joint Air Operations) are found under JPUB 3-0 (Operations).

links that provided 324 DSN voice trunks and 30 automatic digital network (AUTODIN, for record traffic) circuits. At its peak, the JCN included 118 GMF satellite terminals, 12 commercial satellite terminals, 61 TRI-TAC voice and 20 TRI-TAC message switches. This hybrid system supported more than 700,000 telephone calls and 152,000 messages a day. Frequency management was arduous with more than 35,000 frequencies assigned in theater. The installed system in toto proved to be responsive and flexible and was maintained at a 98 percent readiness rate. (Conduct of the Persian Gulf War, April 1992, pp. K-25,K-30)

V. CONCLUSIONS

A. ARMY COMMUNICATIONS INTEROPERABILITY

Army communications is designed and currently capable of both inter-service and combined force (NATO) interoperability. At its base level, interoperability is accomplished from the tactical Mobile Subscriber Equipment (MSE) Node Center Switches (hybrid of TRI-TAC switches) through gateways to inter-service and combined forces. Three notable areas driving the Army's capability to perform communications interoperability are C2 architectures, equipment and doctrine.

1. Command and Control Architectures

The Army's current C2 architecture has evolved from the cold war years with the focus being on large forces deployed in the European theater. This architecture is called the Army Tactical Command and Control System (ATCCS). The basic building blocks of Army core communications in support of ATCCS are Combat Net Radio (CNR), the Army Data Distribution System (ADDS) and the Area Common User System (ACUS). Providing the services of these basic blocks is a constant. There will always be a need to provide the functionality of the three. However, as the National Military Strategy evolves so will the systematic implementation of these functions. Technological advances and the increasing

reliance on digital data transmissions is driving the Army to revise its C3 system. The "Enterprise Strategy" is the Army's view of the future C3 system. Its impact on the future C2 architecture remains to be seen. Smaller, faster and more lethal forces will require an architecture that is responsive, light and flexible.

Within the Unified Command the Army's component relationship in support of JTF operations is also in flux. Under the Unified Command's three tier C2 architecture, service components respond to directives from the CINC in support of the Subunified Commander who had operational control of the CJTF. The two tier approach has streamlined C2. Under this scheme the components provide forces and support directly to the CJTF as directed by the CINC. Thus far Pacific Command is the only Unified Command avidly pursuing a C2 transition from three tier to two. (Joint Task Forces, 8 December 1993, p. 4)

2. Communications Equipment

Desert Shield/Desert Storm proved that the Army's communication equipment is successful in the joint interoperability arena. Inter-service gateway access is accomplished from the Army MSE system via the AN/TTC-39 (voice traffic) and AN/TYC-39 (record traffic). Both are proven TRI-TAC switches and have been fielded to the Army, Air Force and Marines. NATO interface at the tactical level is accomplished

using the NATO Analog Interface (NAI) converter installed at the MSE NC or interfaced using a line of sight (LOS) V2 assemblage. The success of the Joint Communications Network (JCN), although tenuous (see Chapter IV, Section C) during Desert Shield/Desert Storm is proof of inter-service communications interoperability.

Although the C2 system and supporting communications network was successful the question that perhaps should be asked is "Was the communications system effective?" Communications effectiveness in toto is the subject for another thesis.

An analogy for general communications effectiveness can be gleaned from the success of C2 in the joint air war. Despite progress made toward jointness prior to the Persian Gulf War, the U.S. is said to have "bought" its way out of command and control problems by massing its tactical air forces. It has been stated that the U.S. fought big but not smart.[29] The same can be said for the theater C3 system. Assets were pumped into the theater to bolster organic assemblages, and numerous commercial assets were exploited.[30]

Although the Army communication equipment was "successful" in Desert Shield/Desert Storm four shortfalls are

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[29] Winnefeld, 1993, p. 126.

[30] Twelve addition MSE Node Centers were provided to the theater by III and V Corps. More than a dozen commercial satellite local and long-distance carriers participated in Desert Shield/Desert Storm.

of note. First, MSE long haul line of sight (LOS) equipment could not cover the distance of dispersed forces. Secondly, cessation, movement and re-establishment of node centers could not keep pace with the forces. Organic assets were not adequate. For MSE equipped divisions additional node centers were OPCONed to support a "leap frog" scheme of maneuver. TRI-TAC Pulse Coded Modulation (PCM, tactical communications equipment prior to MSE) equipped divisions conducted controlled substitution programs to build additional switching centers to enable "leap frog" operations. Thirdly, engineering circuits through differing switches is time intensive.[31] This engineering burden will continue to recede as the separate services migrate toward like switching systems.[32] Lastly, and perhaps most importantly, was the tenuous ability to effectively transmit record data.[33]

Tactical communications are geared to the warfighter who, in the past, has exclusively used voice, telephone and courier to conduct battle operations and planning.

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[31] See Chapter IV, Section C, 3, b.

[32] The Honorable Mr Emmett Paige, Assistant Secretary of Defense for C3I stated in a letter to SECMILDEPs, ASSTSECDEF (SO & LIC), DIRDISA, DIRDIA, DIRNSA, and DIRJTSTF dated 26 November 1993 that "...interoperability among switched systems within DoD is paramount." It goes on to say "The Joint Staff will validate requirements to ensure that they include necessary functionality for the equipment to operate in a joint network".

[33] For an in-depth discussion on Packet Switched Networks see *The First Information War* by Alan Campen pp. 109-119.

Technological advances have enabled, and the rapidity of battle has forced, commanders to enhance their ability to quickly disseminate battlefield information. Computer systems have been developed to support the commander in this endeavor (e.g., Desert Shield/Desert Storm saw the utilization of the Army Central Forces C2 Information System (AC2IS)). Data generated by these computer systems must be packetized for transmission over the tactical communications system. In support of digital data transmission the Army is fielding a Packet Switched Network (PSN) which will operate over the existing MSE backbone system. Future operations will require a digitized common view of the battlefield. All-source fusion to support a common view is data intensive. PSN is the key to enabling the distribution of this data.

3. Doctrine

Many problems with joint communications interoperability stem from the historical disconcerted approach to joint doctrine.[34] A refocusing on the joint task force and force projection in recent times in conjunction with joint exercises has enabled the identification and rectification of many interoperability concerns. An emphasis on joint operations and exercises alone will not systemically rectify

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[34] A discussion on the evolution of joint operations can be found in *Command and Control of Theater Forces: The Future of Force Projection Operations* by John Cushman (June 1991, pp. 27-48)

all communications interoperability woes. Joint doctrine is the congealing factor to successful communications. Current joint doctrine publications are altruistic yet enigmatic. The Joint Publications System is functioning and correcting these deficiencies. However, in light of recent historic changes and technological advancements will Joint Doctrine be overcome by events? Regardless of the status of joint publications at the time of the next crisis the JTF J6 will establish a Joint Communications Network (JCN) and it will work. A communications template and responsibilities may be vague but the functionality is understood by system engineers and will be executed. Innovative engineering worked during Desert Shield/Desert Storm and will work in the future. The intent of producing succinct doctrine documentation is to enable communications engineers to work in an efficient and timely manner.

B. THE FUTURE

Future operations will continue to be fraught with diverse situations requiring rapid response. The ability to provide communications will be based on acquisition and doctrine decisions made years beforehand. The TRI-TAC program provided a good base for the Army's leap to MSE. MSE's flood search, fixed subscriber number and packet switching capability appear to provide a well grounded base for the next evolution. The communications system of the future must be versatile enough

to support either Low Intensity Conflict (LIC) or High Intensity Conflict (HIC). It must be lightweight to accompany small, fast moving forces. Above all else it must be one synergistic system capable of supporting voice, data and information fusion. Austere force levels dictate that a force be effective. First strike kills are a must. To effectively execute a strike a commander must know the enemy composition and disposition. Sensor support systems must be capable of timely acquisition, tracking and dissemination. Timely dissemination to warfighters requires availability of transmission equipment and bandwidth. It is no surprise that there is an increasing propensity toward the use of satellites in fulfilling long haul transmission routes. This trend is a phenomenon that has been documented by J6Z.

Many requestors of satellite support do not understand the transmission throughput of data and the power required to transmit that data. Figure 26 is a relational depiction of some data "pipes".

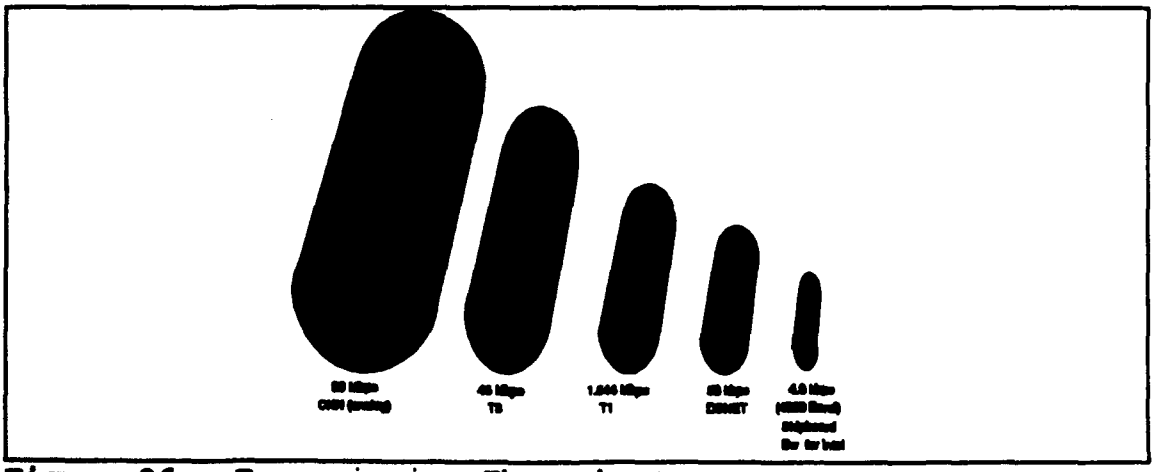

Figure 26. Transmission Throughput

The volume of information transmitted by CNN is apparent (i.e., 90 Mbps). Also depicted are the T3, T1 (typical telephone trunk circuits) and the standard 58 kbps rate for a Data Switched Network (DSNET). Of particular note is the current shipboard bandwidth allocation for intelligence (only 4.8 kbps).[35] To accommodate the volumes of data required for information synergism the shipboard pipe must be larger. Increasing shipboard pipe size is difficult. Part of this problem is driven by the nature of seaborne vessels.

Seaborne vessels do not provide an optimum platform for satellite communications. Limited deck space restricts the size of satellite dishes, and craft roll and pitch reduce the Gain per noise Temperature (G/T). A stable large satellite dish provides for optimum reception of the satellite signal. A comparison of bandwidth capability given the same power output of the satellite, ground dish size, employment (Navy, Ground Mobile Forces (GMF) and Medium/Heavy Terminals (M/T, H/T)) and G/T is depicted in Figure 27. (Woodward, 18 April 1994)

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[35] From *Joint Worldwide Intelligence Communications System (JWICS) System Overview*, p. 5, December 1991.

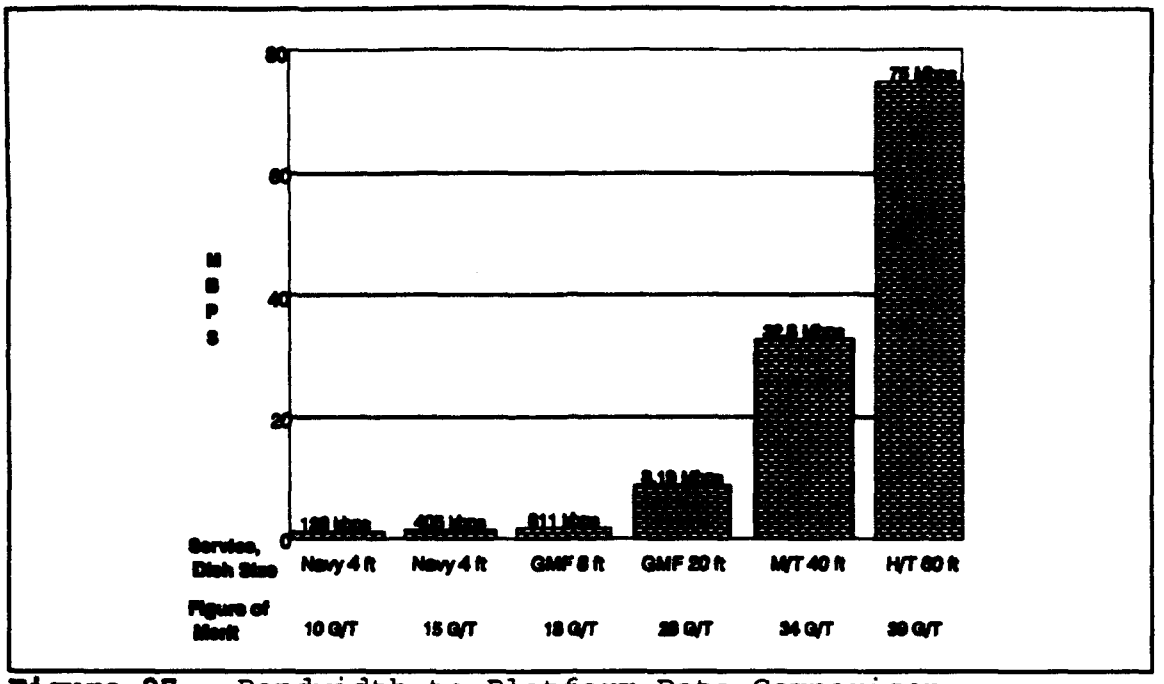

Figure 27. Bandwidth to Platform Data Comparison

1. System Performance

The performance of the future system must be capable of providing an all source synergistic view of the battlefield. Digitization of the battle field is underway now. To support this endeavor current communications shortfalls must be overcome. These include automating the Communications Electronics Operating Instructions (CEOI, or Signal Operating Instruction (SOI)), improving systems engineering management (e.g., frequency deconfliction, communications routing, etc.), reduction in unique software, increasing availability of long

haul assets and effective use of bandwidth.[36] Above all the system must be interoperable.

2. Service Concepts

The Department of Defense and the services have recognized a need for an evolution in the C3 arena. Innovative approaches to effectively employ technological advances is paramount. The Defense Wide view of this new system is called C4I For The Warrior (C4IFTW). The objective of C4IFTW is to:

> ...ensure that all C4I systems in the future be planned, acquired, configured, and integrated appropriately to meet the full spectrum of Joint warfighting needs, and that the Commanders-in-Chief (CINCs), Services, and DOD agencies pursue a common, coordinated, and integrated C4I systems migration strategy and roadmap to achieve C4I for the Warrior (C4IFTW) goals.[37]

The goal of C4IFTW is to provide a unified strategy for the orderly migration from current C4I systems to a fully integrated and interoperable worldwide system. The Army is supporting this migration via its Enterprise Strategy (see Chapter II, Section B, subsection 5). The other Services have

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[36] In the Marine Corps Briefing to the Military Communications Electronics Board (MCEB) on *The Marine Corps Migration Strategy to the GCCS Core Services*, it was stated that over 70 percent of the code is in Computer Software Configuration Items covering nine areas (from mapping/ overlays to system administration)- "each system elected to 'build its own'". (p. 10)

[37] From the *Joint Mission Needs Statement (JMNS) for Achieving the C4I for the Warrior Concept (Coordinated Draft)*, p. 1.

also begun their migration. The Air Force's concept is called "Horizon". The Navy's is "Copernicus".[38]

3. Summary

This thesis provides a synoptic view of the Army structure, C2 architecture, communications equipment, its role in the JTF and JCN responsibilities. Its intent is to provide a perspective on the Army baseline structure, systems and interoperability. Recent changes in the world have placed the United States at a historic crossroad. The National Military Strategy is shifting from a global and theater level warfare perspective to one focused on spontaneous regional and crisis operations. In the face of reducing force levels, technological advances, increasing costs and weapons lethality, commanders must exploit all means available. Communications is an edge that, when used effectively, can provide a commander a force multiplier. This thesis provides insights into the Army's foundation systems from which their future C4I will evolve. The Army's ability to support the National Military Strategy and execute future missions will be a direct function of its C4I capabilities.

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[38] For further information on separate Service C4I migration see: *Horizon, Air Force C4I Strategy for the 21st Century; Moving Navy Communications into the 21st Century* and *Copernicus Functional Description Document (FDD).*

C. SCENARIO

Reference Chapter I, Section D. This is a scenario based view of a future Army C4I system.

1. Communications Equipment

The Army Tactical C2 Airborne Platform (ATC2AP, fixed wing) is equipped for C3 and all source analysis of intelligence inputs. This integration includes information from data bases and sensors (National Technical Means, AWACS, JSTARS, etc.). Four similarly equipped command helicopters exist in the division. One is for the Strike Team Staff (G3, Operations) and one each per brigade. The helicopters are not capable of all source analysis but can take targeting feeds from sensors and the ATC2AP.

Additionally, all aircraft and vehicles have Area of Influence Plasma Screen Displays (AOIPSD). AOIPSD's are artificial intelligence driven graphic displays of all enemy and friendly forces within "influencing" range (different for each platform). Targeting information and priorities can be received from the ATC2AP or helicopter command aircraft.

2. The Mission Unfolds

The Strike Force Commander (SFC) is en route to East Calmorn and begins to receive intelligence downlink information. Airports have been secured and the aviation brigade has established bases of operation at them.

Penetration of the border occurs as the SFC aircraft enters East Calmorn airspace. Intelligence feeds to the ATC2AP provide enemy locations and composition. These appear on the SFC's command console (similar to a Naval Tactical Display System (NTDS) with terrain).

The armor brigade has not completed equipment receipt. The SFC must hit the enemy quickly and hard. The aviation brigade is scrambled. Targeting will occur on the move.

The aviation brigade is deployed with scouts forward, heavily armed helicopters follow with the brigade command helicopter in trail. The SFC gives his priorities for strikes to the G3 helicopter and the aviation brigade commander.

The aviation brigade engages the enemy. Automatic sensor feeds to the helicopters continue during the battle. Engagements are monitored by the SFC and G3 as the aviation brigade fights the battle. The enemy advance is neutralized, their remaining forces withdraw.

3. Recapitulation

Although the above scenario is fictitious, some aspects may come to fruition in the near future. JSTARS' ability to deliver data to a helicopter has already been demonstrated. A continuing theme throughout this thesis has been the Army's move toward improving its ability to transmit intelligence over existing networks and equipment. Mobile Subscriber Equipment (MSE), Single Channel Ground and Airborne

Radio System (SINCGARS) and the Enhanced Position Location Reporting System (EPLRS) are just some of the base elements of the Army's C3 system. A view of the digital battlefield will be transmitted over these or like hybrid systems. When linked to satellite and sensor systems it will be capable of supporting the functionality demonstrated in the above scenario. What the Army needs to do is examine its force structure, training and doctrine in light of these advances. (Journal of Electronic Defense, January 1994, pp. 36-37)

While current inter-service communication is successful it must become efficient in anticipation of an increased traffic load. Cyrus the Great, founder of the Persian Empire had inscribed on his palace wall: "Mene Mene Tekel Upharsin," which translates to "Thou Art Weighed in the Balance and Found Wanting."[39] War is unforgiving. Warriors, like doctors, bury their mistakes. The warrior is increasingly reliant on electronic C3I systems in the prosecution of battle. When the Joint Communications System of the future is "weighed in the balance" it must be capable of rising to the task.

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[39] Rouse, 1991, pp. VI-VII.

APPENDIX A. ACRONYMS

AADC	Area Air Defense Commander
ACR	Armored Cavalry Regiment
ACUS	Area Common User System
ADA	Air Defense Artillery
ADDS	Army Data Distribution System
AFATDS	Advanced Field Artillery Tactical Data System
AFFOR	Air Force Forces
AFSOB	Air Force Special Operations Base
AG	Adjutant General
AM	Amplitude Modulated
APC	Armored Personnel Carrier
AR	Armor
ARFOR	Army Forces
ASAS	All Source Analysis System
ATCCS	Army Tactical Command and Control System
AUTODIN	Automatic Data Network
AUTOVON	Automatic Voice Network
AV	Aviation
BAS	Battlefield Automated System
BFA	Battlefield Functional Area
BFV	Bradley Fighting Vehicle
BOS	Battlefield Operating System

CAS	Close Air Support
CE	Communications and Electronics
CINC	Commander in Chief
CNR	Combat Network Radio
COMARFOR	Commander Army Forces
COMAFFOR	Commander Air Force Forces
COMJSOTF	Commander Joint Special Operations Task Force
COMLANFOR	Commander Land Forces
COMMARFOR	Commander Marine Forces
COMNAVFOR	Commander Navy Forces
COMSEC	Communications Security
CONUS	Continental United States
COSCOM	Corp Support Command
CP	Command Post
CRC	Control and Reporting Center
CSP	Call Service Position
CS	Combat Support
CSS	Combat Service Support
C2	Command and Control
C2I	Command, Control and Intelligence
C3	Command, Control and Communications
C4	Command, Control, Communications and Computers
DCS	Defense Communications System
DF	Direction Finding
DISA	Defense Information Systems Agency
DISCOM	Division Support Command

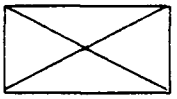
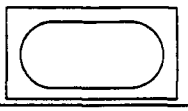
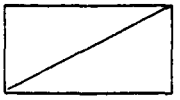
DNI	Digital NATO Interface
DNVT	Digital Non-Secure Voice Terminal
DS	Direct Support
DSCS	Defense Satellite Communications System
DSVT	Digital Subscriber Voice Terminal
EAC	Echelons Above Corps
ECM	Electronic Counter Measures
EMCON	Emissions Control
ENG	Engineers
EPLRS	Enhanced Position Location Reporting System
FA	Field Artillery
FAADS	Forward Area Air Defense System
FLOT	Forward Line of Troops
FM	Field Manual
FM	Frequency Modulated
FS	Fire Support
FSB	Forward Support Battalion
FTOP	Fleet Telecommunications Operating Procedures
GMF	Ground Mobile Forces
GTE	General Telephone and Electronics
HF	High Frequency
HHC	Headquarters and Headquarters Company
HMMWV	High Mobility Multi-Wheeled Vehicle
HQ	Headquarters
IEW	Intelligence/Electronic Warfare
INCA	Intelligence Communications Architecture

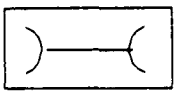
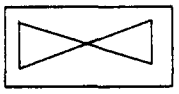
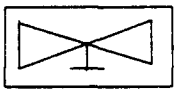
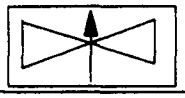
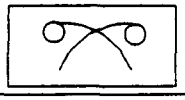
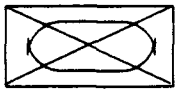
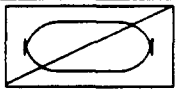
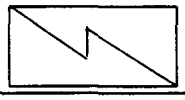
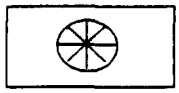
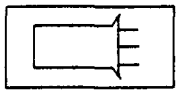
IOM	Installed, Operated and Maintained
ISB	Intermediate Staging Base
JCCC	Joint Communications Control Center
JCSE	Joint Communications Support Element
JIC	Joint Intelligence Center
JOA	Joint Operational Area
JTAO	Joint Tactical Air Operations
JTF	Joint Task Force
JSOTF	Joint Special Operations Task Force
KW	Kilowatt
LAN	Local Area Network
LEN	Large Extension Node
LENS	Large Extension Node Switch
LOS	Line of Sight
LRIP	Low Rate Initial Production
MARFOR	Marine Forces
MEU	Marine Expeditionary Unit
MSE	Mobile Subscriber Equipment
MSRT	Mobile Subscriber Radiotelephone Terminal
NAI	NATO Analog Interface
NATO	North Atlantic Treaty Organization
NAVFOR	Navy Forces
NCA	National Command Authority
NCS	Node Center Switch
NMF	Node Management Facility
NRI	Net Radio Interface

NSWTG	Navy Special Warfare Task Group
PCM	Pulse Coded Modulation
QM	Quartermaster
RAU	Radio Access Unit
RITA	Reseau Integre de Transmissions Automatique
RMC	Remote Multiplexer Combiner
RNG EXT	Range Extension
RRAU	Remote Radio Access Unit
RWI	Radio to Wire Interface
SATCOM	Satellite Communications
SCC	System Control Center
SEN	Small Extension Node
SF	Special Forces
SHF	Super High Frequency
SINCGARS	Single Channel Ground and Airborne Radio System
STANAG	Standardization Agreement
SYSCON	System Control
TAC	Tactical Command Post
TACC	Tactical Air Control Center
TACP	Tactical Air Control Party
TACSAT	Tactical Satellite
TM	Technical Manual
TOC	Tactical Operation Center
TO&E	Table of Organization and Equipment
TROPO	Tropospheric
UHF	Ultra High Frequency

WAN	Wide Area Network
WOC	Wing Operations Center
VHF	Very High Frequency

APPENDIX B. SYMBOLOGY

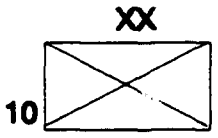
SYMBOL	DESCRIPTION	ABBREVIATION
	Section or Squad	SEC, SQD
	Platton or Detachment	PLT, DET
I	Company, Battery or Troop	CO, BAT, TRP
II	Battalion or Squadron	BN, SQDRN
III	Group or Regiment	GRP, REG
X	Brigade or Equivalant	BDE
XX	Division	DIV
XXX	Corps	CRP
	Infantry	INF
	Armor	AR
	Recon or Cavalry	RECON, CAV
	Engineer	ENG
	Artillery	ARTY

SYMBOL	DESCRIPTION	ABBREVIATION
	Medical	MED
	Maintenance	MNT
	Aviation	AV
	Avaition (Rotary)	
	Attack Helicopter	
	NBC	NBC
	Air Defense Artillery	ADA
	Mechanized Infantry	MECH INF
	Armored Recon (CAV)	ARC
	Armored Artillery (Self Propelled)	AARTY (SP)
	Signal/Commo	SIG
	Transportation	TRANS
	Psychological Operations	PSYOPS

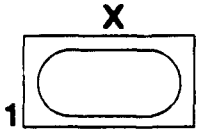
SYMBOL	DESCRIPTION	ABBREVIATION
CA	Civilian Affairs	CA
PERS	Personnel	PERS
	Finance	
AG	Adjutant General	AG

EXAMPLES :

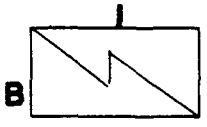
: III Corps



: 10th Infantry Division, III Corps



: 1st Brigade (Armor), 10th Inf Div, III Corps



: B Comapany, 124th Sig Bn, 4th Div

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